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THE AUTHORS OF THE SEVERAL PAPERS ARE SEVERALLY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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ERRATA.

Vol. XXV. (New Series), Part II.

Page 359, lines 9 and 10—
For "subtle and angular" read "subhexangular."
Page 361, line 15—
For "obilqua" read "obliqua."
Page 361, line 17—
For "they they" read "then they."
Page 361, line 21—
For "Harwell" read "Haswell."
Page 362, line 12—
For "bacata" read "baccata."
Page 362, line 20—
For "30" read "20."

[PROC. ROY. SOC. VICTORIA, 26 (N.S), PT. I., 1913.]

ART. I.—*Contributions to the Flora of Australia, No. 20.*[1]

BY

ALFRED J. EWART, D.Sc., PH.D.

(Government Botanist of Victoria and Professor of Botany and Plant Physiology in the University of Melbourne).

AND

BERTHA REES

(Lecturer on Botany, University of Melbourne).

(With Plates I.-II.)

[Read 13th March, 1913].

AMSINCKIA LYCOPSOIDES, Lehm. (Boraginaceae).

Near Benalla, Victoria, Hon. Mr. Little, M.L.C., 29/8/1912.

Not previously recorded as growing wild in Victoria. A native of California, but not yet sufficently established to be considered naturalised.

ANTHOCERCIS MYOSOTIDEA, F. v. M. (Solanaceae).

Jeparit, Victoria, W. R. A. Baker, 14/10/1912.

BASSIA LANICUSPIS, F. v. M. (Chenopodiaceae).

Mildura, Victoria, H. B. Williamson, No. 1480, September, 1912.

This is a new record for Victoria, but previous specimens (Murray River, Wimmera, etc.) have been placed under *Bassia diacantha* var. *longispinea*. This variety was queried by Bentham, and can undoubtedly best be placed under *B. lanicuspis*, no special varietal designation then being necessary.

CARDAMINE HIRSUTA (C. parviflora), "Small-flowered Bitter Cress." (Cruciferae).

Mildura, Victoria, H. B. Williamson, 4/9/1912.

The form usual in Australia is glabrous, or rarely with a few whitish hairs at the base. This specimen is sparsely hairy on stem and leaves, with white, scattered, usually bifurcate, tri-radiate or even stellate hairs.

1. No. 19 in Proc. Roy. Soc. Victoria, vol. xxv. (n.s.), p. 105, 1912.

Celtis philippinensis, Blanco. (Zizyphus melastomoides, Cunn.). (Urticaceae).

Tropical Australia, A. Cunningham, 1818-1821.

This plant was in the Herbarium under the name *Zizyphus melastomoides*, A. Cunn., but does not occur in Mueller's Census. In Benth. Fl. Aust. Vol. 1, p. 412, and in the Index Kewensis, *Z. melastomoides*, A. Cunn., is given as a *Celtis sp.*, but no definite, specific name is given.

The specimen agrees closely with the type specimen of *C. philippin ensis*, and hence must be placed as a synonym to that species.

Cyanostegia microphylla, S. Le Moore. (Verbenaceae).

Spencer le Moore (Journal of Botany, vol. xli. 1903, page 100), states that this new species is identical with the Elder Exporing Expedition specimen marked by Mueller as *C. Turczaninowii*. Baron von Mueller under this name included 3 varieties. Variety *angustifolia* (*C. angustifolia*, Turcz.), var. *lanceolata* (*C. lanceolata*, Turcz.), and var. *dentata* (*C. microphylla*, S. le Moore). All three species appear to be distinct.

The full list of localities for *C. microphylla* will therefore be:—Coolgardie district, L. C. Webster, 1897 and 1902, Menzies, Diels, 1903; Gnarlbine, Helms, Elder Exploring Expedition, 1891; Southern Cross and Parker's Range, E. Merrill, 1890; Yilgarn, near Mt. Moore, King and Lefroy, 1899; between Victoria Springs, Ularing, and Mt. Jackson, Young, October, 1873.

All are Western Australian localities.

Cytisus linifolius, Lam. "Flax Broom." (Leguminosae).

Talbot, Victoria, G. Porter, 1885; Pakenham and Nar Nar Goon, Victoria, J. W. Audas, November, 1912.

A native of the Mediterranean region. This plant has now evidently established itself in various localities, and may be classed as a naturalised alien in this State. It is often grown in gardens.

Desmazeria acutiflora (Nees.), Dur. and Schinz. (Brizopyrum acutiflorum, Nees; Eragrostis acutiflora). (Gramineae).

Identified by Professor Hitchcock.

Castlemaine, Victoria, J. P. McLennan, May, 1911; Bendigo, Victoria, J. P. McLennan, November, 1911; Veterinary School Grounds, Melbourne, October, 1912, L. C. Bartels; Raglan, Victoria, H. B. Williamson, December, 1912.

This grass is a native of South Africa, and appears to have naturalised itself as an alien in Victoria. It appears to grow in dry situations, but is apparently too stiff and harsh to be of much value as a grazing plant. It has no injurious properties so far as is known.

DIURIS PUNCTATA, Sm., var. ALBA. (Orchidaceae).

Sydenham, Victoria, P. R. H. St. John, October, 1912.

This is given in Bentham's Flora as *D. alba*, the chief distinction being the white flowers with smaller parts. The flowers may vary from pure or nearly pure white to white with purple spots or lines, or diffusely purple nearly all over, and some of the most purple flowers were also the smallest. The plant is evidently a variety only of *D. punctata.*

DODONAEA TRIQUETRA, Wendl. "Large-leaved Hopbush." (Sapindaceae).

Heathcote, Victoria, W. J. Stephens, December, 1912.

Recorded in Mueller's "Key to the System of Victorian Plants," as from the East only.

EUCALYPTUS PERRINIANA, author ? (Myrtaceae).

The first published description of this plant is given by Rodway, in the Papers and Proceedings of the Royal Society of Tasmania, p. 181, 1893. Rodway gives the name as *E. Perriniana*, F.v.M., and refers to the plant as being described at the meeting of the Association for the Advancement of Science, Melbourne, 1890. No such name is printed in the Proceedings, and in Mr. Perrin's paper on Tasmanian Eucalypts, a reference merely occurs to a specimen No. 2, which he thought would prove to be a new species. The species appears to be not merely Tasmanian, but also to grow in Victoria and New South Wales—(Dargo High Plains, Victoria, Dr. Heber Green, January, 1913; Tingiringi Mountain and Snowy Mountains, New South Wales, W. Bauerlen). According to the Congress rules, the authority for the name would be Rodway, who first published the name and description, although he assigned the name to Baron von Mueller, apparently being under the impression that a name and description had been published in 1890.

EUCALYPTUS SMITHII, R. T. Baker. "Gully Gum." (Myrtaceae).

Gippsland, Victoria, Mr. Howitt, March, 1879.

Previously placed as a variety of *E. Stuartiana*, F.v.M., near to *E. rostrata.* The species will be an addition to the Flora of Victoria.

Galium Gaudichaudi, D.C. (Rubiaceae).

Bentham (Flora Aust., vol. iii. p. 446) gives this species as valid, but suggests that it may not really be distinct from the New Zealand *G. umbrosum*. Baron von Mueller (Fragm. vol. ix. p. 188) accepted this suggestion. There seems, however, as good reason to uphold *G. Gaudichaudi* as in the case of any other species of Galium, provided that the variety *muriculatum* is transferred to *G. umbrosum*, with which it closely agrees, except as regards the surface of the fruit. *G. Gaudichaudi* then includes a series of forms with narrow leaves, with recurved margins, showing an increasing tendency to develop a rough hispid character. Both *G. Gaudichaudi* and *G. umbrosum* may therefore be regarded as valid Victorian species of very distinct habit and facies, but closely related as regards flower and fruit. Both species are natives of Tasmania, Victoria, South Australia and New South Wales, and *G. Gaudichaudi* appears to be the commoner of the two. *G. umbrosum* occurs in New Zealand, but not *G. Gaudichaudi*.

Gastrolobium Laytonii, J. White. (Leguminosae).

In Proc. Roy. Soc. Vict., 23, 1910, p. 111, for "the under surfaces of the leaves covered with felt-like greyish hairs," read "leaves practically glabrous on both surfaces." The shape of the leaf varies from obtuse, or narrow oblong, to pointed cuneate on the same branch. Additional localities are Day Dawn, West Australia, J. A. McClellan, 20/9/1912. A scrap of the same species without definite locality or number also exists among J. Drummond's West Australian plants. It was included under *G. crassifolium*.

Gaudinia fragilis, Beauv. (Gramineae).

Det. A. S. Hitchcock, Agrostologist to the Department of Agriculture, U.S. America.

Warrnambool, Victoria, H. Hauschildt, 1912.

A native of the Mediterranean region. An unrecorded introduced grass for Victoria, and may eventually become sufficiently established to be considered naturalised.

Gnaphaloides uliginosum, A. Gray. (Compositae).

Mt. Alfred, near Walwa, Victoria, A. J. Ewart, November, 1912.

Only recorded in Baron von Mueller's Key from the North-West and South-West of Victoria.

GOMPHRENA INVOLUCRATA, Ewart, n. sp. (Amarantaceae).

A stiff, erect, apparently annual herb, the rigid cylindrical stems softly hairy when young, more or less glabrous when older. Leaves opposite, flat linear lanceolate, acute, densely hairy beneath, more sparsely so on the upper surface, over an inch in length. Flowers in hemispherical heads about three-quarters inch diameter at the ends of the branches, surrounded by an involucre of 10 to 20 linear lanceolate leaves. Bracts and bracteoles, thin transparent scarious, keeled, ovate pointed, 7 mm. long. Perianth segments about 6 mm. long, linear obtuse, very woolly on the back below the middle. Anther tube longer than the ovary, the free portion flattened, the sterile lobes between the anthers slightly longer than them, and each divided into two short blunt lobes. Style filiform. Stigma bifid. One brown flattened slightly curved seed. Near Pine Creek, Northern Territory, J. H. Niemann, April, 1904. The specimen consists of the heads only with a small portion of the stem, but the plant is readily distinguished from *G. canescens*, R. Br., by the involucre, the broader bracts and bracteoles, the blunt perianth segments very woolly on the back, and the flat bilobed free segments of the staminal tube.

HOVEA LONGIFOLIA, R. Br., var. ASPERA. (Leguminosae).

Victoria: Bogong Ranges and Mitta Mitta River, Dr. F. Mueller, January, 1854; Snowy River, Dr. F. Mueller, February, 1854; Munyang Mountains, Dr. F. Mueller, 1874; Grampians, Et. Eloy Dalton, Warburton, G. Weindorfer, 1904; Yarra Junction, P. R. H. St. John, 1910. New South Wales: Bunberry, near Molong, J. H. Maiden, August, 1897.

The roughness of the leaves is so pronounced as to justify the recognition of an additional variety of this species. Some specimens of it have been placed under the variety "*rosmarinifolia.*" The variety "*aspera,*" was first recognised by F. M. Reader in a manuscript name, apparently unpublished.

INDIGOFERA AUSTRALIS, Willd. "Austral Indigo." (Leguminosae).

Healesville, Victoria, C. French, Junr., October, 1912.

A white flowered form.

ISOËTES DRUMMONDII, A. Braun. (Rhizospermae).

Pine Mountain, between Tintaldra and Dalwa, Upper Murray, Victoria, A. J. Ewart, November, 1912.

In pools on summit, in granite basins on bare rock.

LACTUCA SCARIOLA, L. "Prickly Lettuce." (Compositae).

Benalla, Victoria, W. B. Tiernan, January, 1913; Rutherglen, Victoria, G. H. Adcock, January, 1913.

A native of Europe and Central Asia, not previously recorded for Victoria as a naturalised alien. It is an annual or biennial weed of no economic value, and apt to be spread readily by its flat seed-like fruits, provided with a parachute mechanism of pappus hairs.

LIMOSELLA AQUATICA, L. (Scrophulariaceae).

This little cosmopolitan plant varies somewhat in different parts of the world. The Australian specimens usually have more or less linear leaves, as shown in Figure I. Occasionally, however, specimens occur with oblong or almost spathulate leaves (J. P. Eckert, Murtoa, Victoria, 1912), and this is the common form in Europe and Asia.

LINARIA PELISSERIANA, L. (Scrophulariaceae). "Pelisser's Toad Flax."

Guy's Forest and various localities along the Upper Murray, and Corryong and Cudgewa Valleys, Victoria, A. J. Ewart, 6/11/1912.

LINARIA VULGARIS, L. Common Toad Flax.

Nullawarre (Allansford), J. Carter, March, 1913. A garden plant previously recorded as a naturalised alien in the East of Victoria, and now also recorded from the West.

MICROCALA FILIFORMIS, H. and L. "Slender Microcala." (Gentianaceae).

Linton, Victoria, H. B. Williamson, No. 1484, November, 1912.

MICROCALA QUADRANGULARIS, Griseb. "Quadrate Microcala."

Agricultural High School, Ballarat, E. J. Semmens, November, 1912; Wangaratta, Victoria, E. E. Pescott, September, 1901.

This interesting genus is small both in size and species. *M. filiformis* is native to the Mediterranean area extending from North Germany to Asia, while *M. quadrangularis* is native to South America, and also occurs in California, possibly as an introduction. Externally the plant suggests the native *Sebaea ovata*, and the Wangaratta specimen from Walter's collection was placed under that species as a small form of *S. ovata*. The former has, however, a cup-like quadrangular calyx, while the latter has the calyx divided to the base.

Probably both *M. filiformis* and *M. quadrangudaris*, whose seeds are very minute, have been introduced with imported seeds, and have been growing in Victoria for some time, but overlooked on account of their small size, or confused with *Sebaea ovata*.

MICROMYRTUS MICROPHYLLA, Benth. (Myrtaceae).

Pine Mountain, between Tintaldra and Walwa, Victoria, A. J. Ewart, 5/11/1912.

MODOLIA MULTIFIDA, Moench. "Red-flowered Creeping Mallow." (Malvaceae)

Spreading along the Upper Murray above Tholgolong, Victoria, A. J. Ewart, November, 1912.

MYAGRUM PERFOLIATUM, L. "Musk Weed." (Cruciferae).

Wimmera Shire, Victoria, J. R. Tovey, January, 1913.

A native of Europe and West Asia, naturalised in Victoria for some years, but hitherto overlooked. Probably first appeared between 1900 and 1904, and "is now spread north over an area of about ten miles from east to west, and five miles north to south, lying twenty miles north of Horsham, and west of Yarrambiack Creek." (Dr. S. Cameron).

An allied plant *Neslia* (*Myagrum*) *paniculatum* is a troublesome weed in Canada. The present species interferes with harvesting by blocking the reaper, and it has been proclaimed for the whole State.

OLEARIA SPECIOSA, Hutchinson. (Compositae).

In Curtis's Bot. Mag. Tab., 8118 (1907).

The locality given is Australia.

This plant was raised in the Royal Botanic Gardens, Kew, England, from seed received in 1888 from the Botanic Gardens, Melbourne. We have received dried specimens, collected in the Grampians, Victoria, by W. R. A. Baker, March, 1888, also from Hall's Gap, Grampians, H. B. Williamson, December, 1902 and 1904, which agree with the type specimen received from the Kew Herbarium, thus giving a precise locality for the species. The species may hence be added to the list of plants native to Victoria. The leaves of the type specimen have rounded tips, but the leaves appear to vary from round to pointed (Mr. Baker's specimen), and forms with entirely pointed leaves appear to approach towards *Olearia myrsinoides*, F.v.M. var. *erubescens*. The relationship of this variety to the above species needs further investigation.

Persoonia juniperina, Labill., var. **sericea**, Ewart and Rees, n. var. (Proteaceae).

Grampians, Victoria, A. G. Campbell, 10/10/1911, and 27/1/1912.

Differs from type specimen in being larger and more hairy. Leaves rather more than one inch in length, and 1—1.5 lines broad, and covered with short silky hairs, which are more conspicuous on the younger parts.

Flowers are also larger, being 6 lines long as compared with 4—5 lines in *P. juniperina*.

Potentilla recta, L. "Erect Potentil." (Rosaceae).

Mitta Mitta Valley, Noorongong District, Victoria, Mr. Paton, December, 1912.

A native of Europe and North Asia, previously recorded in Victoria from the Western District. It is now evidently establishing itself as a naturalised alien in Victoria.

Ranunculus sardous, Crantz. (Ranunculaceae).

Port Franklin, December, 1912, H. B. Williamson, No. 1498, "The moisture-loving Crowfoot."

The plant is a native of Europe, North Africa, and Asia Minor, and is probably a garden escape. It has not previously been recorded as growing wild in Victoria, The present specimens from the sea coast have the flowers a brighter, deeper yellow than usual, and the fruits are smooth, as in the variety, *angulatus* (formerly recognised as a distinct species) instead of with a row of minute tubercles on each face of the fruit.

Rapistrum rugosum, All. "Giant Mustard or Turnip-weed." (Cruciferae).

Bacchus Marsh, Victoria, J. R. Tovey, November, 1910.

Naturalised in the Bacchus March district in cultivated land and waste places, and evidently introduced with imported seeds.

The plant is a native of South and Central Europe, where it is common in corn crops. It has no known economic value, and is a freely seeding weed, troublesome on account of its seedlings fouling the seed bed for the young corn. It is already recorded as a naturalised alien in South Australia.

REESIA, Ewart. nov. gen. (Amarantaceae).

Flowers hermaphrodite, perianth segments 5, free, overlapping but nearly equal; stamens 5, forming a short staminal tube; anthers two-celled, on long filaments alternating with flat lobes bifid at the end, the lobes and stamens of nearly equal length. Ovary one-celled, style long and slender, stigma capitate. Fruit a capsule, splitting by 3 apical boat-shaped valves of equal size and shape. Seeds kidney shaped, more than one.

REESIA ERECTA, Ewart, n. sp.

A herb, with slender but stiff and erect slightly hairy stems, bearing terminal white scaly clusters of flowers in an irregularly dichotomous cyme. Leaves opposite, sessile, about 5 lines long, linear acuminate, each with a basal pair of small narrow pointed membranous scaly stipules with entire or fringed edges.

Flowers each with a pair of nearly equal scaly bracts. Perianth segments $2\frac{1}{2}$ to 3 lines long, with a clearly defined midrib, and free from hairs on both sides. Seeds brown, slightly curved, flat on the sides, minutely tuberculate. Four seeds in each ripe fruit.

Near Pine Creek, Northern Territory, J. H. Niemann, August, 1904.

This plant, in general appearance and habit, as well as in the structure of the flower, appears to come between *Alternanthera* and *Gomphrena*. It differs from both genera mainly in the dehiscent capsular fruit, with several insead of a single seed, and also from *Gomphrena* in the capitate stigma. The long filaments and glabrous perianth segments are also diagnostic features.

To place a multiseminate genus among the uniseminate series of the Amarantaceae may seem an abnormality, but the plant appears to have no other affinity to the series (Celosiaae) with several seeds A few species of *Celosia* have in fact only one seed, and the reverse is shown by *Reesia*. Possibly too much importance is attached to the number of the seeds in the classification of the Amarantaceae.

SENECIO DALTONI, F. v. M. (Compositae).

This plant was recorded by the late Mr. C. Walter (Vict. Nat. xvi., 1899, p. 99) as new to Victoria (North-West). The specimen (Mallee, Victoria, C. French, Junr., October, 1898) proves to be *Senecio Jacobaea*, the common Ragwort, a naturalised alien proclaimed for certain shires.

STACHYS ARVENSIS, L. "Woundwort or Stagger-weed." (Labiatae).

Pine Mountain, between Tintaldra and Walwa, Victoria, A. J. Ewart, 5/11/1912. A naturalised alien.

TUNICA PROLIFERA, Scop. (Caryophyllaceae).

Mt. Alfred, near Walwa, A. J. Ewart, November, 12th, 1912.

URENA LOBATA, L. (Malvaceae).

Near Pine Creek, Northern Territory, J. H. Niemann, August, 1904.

VERBASCUM BLATTARIA, L. (Scrophulariaceae).

Common along Upper Murray, Victoria, A. J. Ewart, November, 1912. A long naturalised alien.

WESTRINGIA EREMICOLA, A. Cunn. (Labiatae).

Ellam, between Jeparit and Rainbow, Victoria, W. R. A. Baker, 12/10/12.

This species was considered by Baron von Mueller to be a variety of *Westringia longifolia*, F.v.M., and was omitted from his second Census of Australian Plants. The general habit, pubescent calyx and strongly revolute leaves readily distinguish it from the closely allied *W. longifolia*, which is a native of New South Wales only, and has flat leaves and a glabrous calyx, *W. eremicola* was only previously recorded in Victoria from the East.

WESTRINGIA RIGIDA, R. Br. (Labiatae).

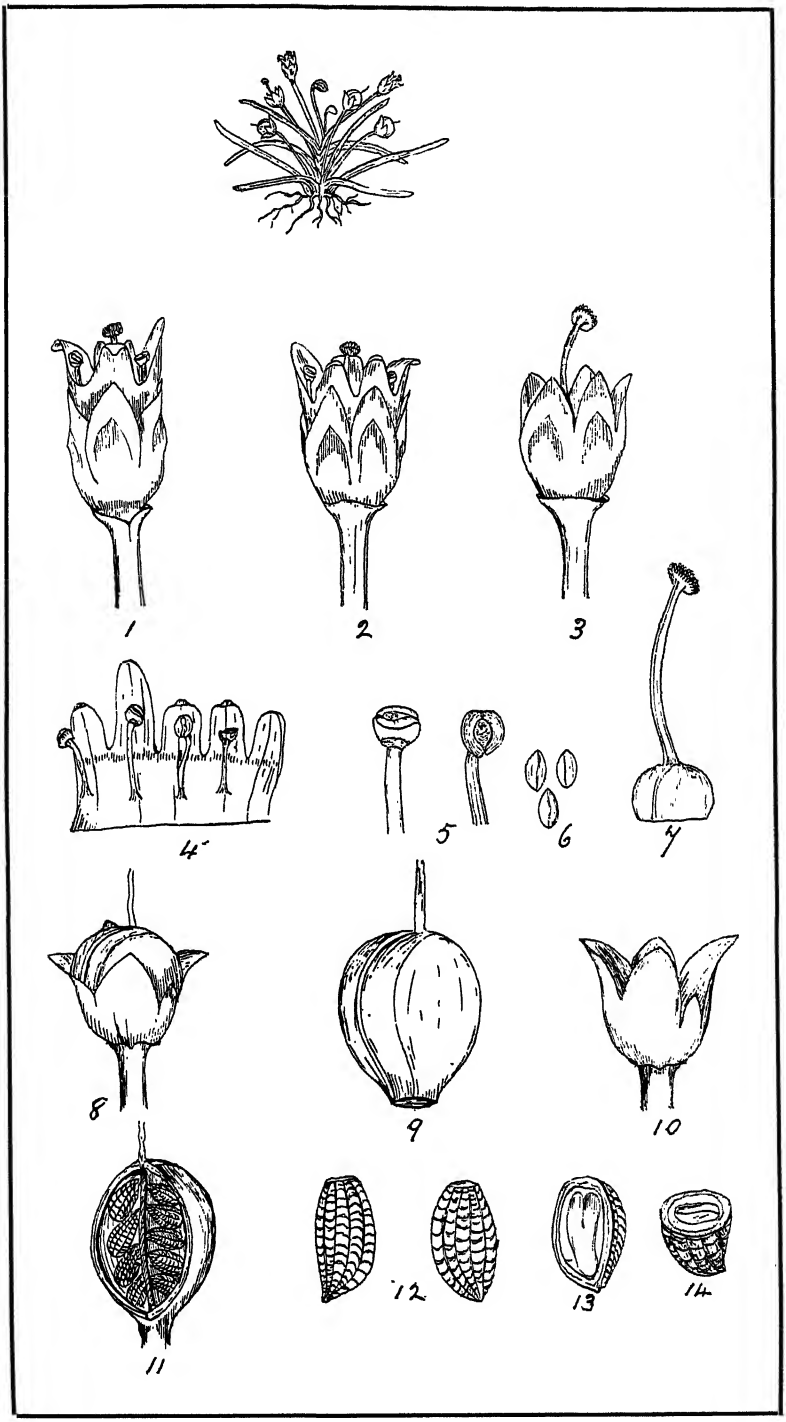
Near Dimboola, Victoria, St. Eloy Dalton, 12/11/1899,

Ellam, between Jeparit and Rainbow, Victoria, W. R. A. Baker, 12/10/1912.

ZYGOPHYLLUM OVATUM, Ewart and White. (Journ. and Proc. Roy. Soc. New South Wales, 1908, p. 197). (Zygophyllaceae).

Mildura, Victoria, H. B. Williamson, September, 1912.

New to Victoria, and possibly often overlooked on account of its small flowers, since when not in fruit it resembles *Z. ammophilum*. In the original description for "petals about half the length of the sepals," read "petals from about half the length of the sepals to nearly the same length." In regard to it Mr. Williamson writes: "It seems remarkable that I gathered at Mildura all the Victorian *Zygophyllums*. The little annual 1468 seems to be one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not recorded for Victoria. The petals are white and minute, and the fruit not truncate, like *Z. ammophilum*. Unfortunately, I got only two specimens of it."

It is certainly curious that this Victorian plant should have been first described from West Australian specimens, and possibly it may be found in other Victorian (and possibly also South Australian) localities.

EXPLANATION OF PLATES I.—II.

PLATE I.—LIMOSELLA AQUATICA, L. (Scrophulariaceae).

Fig. 1, 2 and 3.—Flower magnified.
4.—Flower cut open.
5.—Stamens.
6.—Pollen grains.
7.—Ovary, Style and Stigma.
8 and 9.—Fruit.
10.—Fruiting Calyx.
11.—Fruit cut open.
12.—Seeds.
13—Seed in longitudinal section.
14.—Seed in tranverse section.

PLATE II.—REESIA ERECTA, Ewart. (Amarantaceae), n. gen. and sp.

Fig. a.—Portion of plant.
b.—Leaves and stipules enlarged.
c.—Single flower with bracts (enlarged).
d.—Stamens and lobes (enlarged).
e.—Gynaecium.
f.—Fruit dehiscing.
g.—Seed.

[PROC. ROY. SOC. VICTORIA, 26 (N.S.), PT I., 1913].

ART. II.—*On Bitter Pit and the Sensitivity of Apples to Poison.*

BY ALFRED J. EWART, D.Sc., PH.D.

(Professor of Botany and Plant Physiology in the Melbourne University).

[2ND PAPER.]

(With Plates III.-V.).

[Read 13th March, 1913.]

In the first paper[1] a detailed account of the action of various poisons on the pulp cells of apples was given, and their extreme sensitivity to certain metallic poisons shown. This sensitivity was so great that it was possible to produce pitting in apples by quantities of lead, mercury and copper so minute as to be incapable of detection, even by delicate methods of technical analysis, at least with the quantities of material available.

Many points still remained open, however, both in regard to the influence of external conditions upon the sensitivity of apples to poison, and also in regard to the bearing of the facts observed upon the problem of bitter pit. In addition, Mr. McAlpine has recently published a voluminous report on bitter pit, in which he confidently assumes that bitter pit and poisoning have no relationship.

The influence of temperature on poisoning.

It has long been known that at low temperatures or when in cool storage, the development of bitter pit is retarded, and Scott (Phytopathology, 1911, p. 32) found the same to be the case with the development of the spots, which he concluded were due to spraying with arsenate of lead. Hence it was of interest to determine the influence of temperature upon the formation of pits by direct poisoning. The method used was as previously described. Apples were floated each in 1 litre of the poisonous solution after removing fragments of the cuticle of approximately a square millimetre in area, from points 1 or more centimetres apart around the periphery of the apple. (See table I.)

1 Proc. Roy. Soc. Victoria, vol. xxiv., 1912, p. 367.

TABLE I. MERCURIC CHLORIDE. STATESMAN APPLES.

Strength of Solution.	At 25°C.—26°C. After $2\frac{1}{2}$ days' immersal.	At 25°C.—26°C. After $3\frac{1}{2}$ days in air.	At 10°C.—11°C. After $3\frac{1}{2}$ days' immersal.	At 10°C.—11°C. After $3\frac{1}{2}$ days in air.	At 0°C.—1°C. After $3\frac{1}{2}$ days' immersal.	At 0°C.—1°C. After $3\frac{1}{2}$ days in air.
1 per 10,000	Brown areas 8–12 mm. diameter nearly confluent.	Pits coalesced to ring of dead tissue 1–3 mm. broad and 2–10 mm. deep.	Spots[1] pale brown 3–6 mm. diameter.	Pits 5–10 mm. diameter and 2–5 mm. deep.	Pale brown spots 1–2 mm. diameter.	Pits 3–5 mm. diameter and 1-2 mm. deep.
1 per 100,000	Pale brown areas 3–5 mm. diameter.	Pits 4–10 mm. diameter and 2–5 mm. deep.	Spots very pale and 1–2 mm. diameter.	Pits 2–3 mm. diameter and 1–2 mm. deep.	Very faint superficial browning.	Pits 1–2 mm. diameter and 1 mm. deep.
1 per 1,000,000	Very pale spots 1–2 mm. diameter	Pits 3–5 mm. diameter and 2–3 mm. deep	Faint browning on shaded side only 1mm. diameter	Superficial browning to pits 1 mm. diameter and depth.	No signs of poisoning	No signs of poisoning.
1 per 10,000,000	No distinct signs of poisoning.	From superficial browning to pits 2 mm. diameter and depth.	No distinct signs of poisoning.	From faint superficial browning to no signs of poisoning.	No signs of poisoning	No signs of poisoning.

1 The largest spots are usually on the paler shaded side, which appears to be more sensitive to poison.

TABLE II. COPPER SULPHATE. YATES PIPPIN.

Strength of Solution.	At 28°C.—30°C. After $3\frac{1}{2}$ days' immersal.	At 28°C.—30°C. $3\frac{1}{2}$ days in air.	At 12°C.—13°C. After $3\frac{1}{2}$ days' immersal.	At 12°C.—13°C. $3\frac{1}{2}$ days in air.	At 0°C.—1°C. After $3\frac{1}{2}$ days' immersal.	At 0°C.—1°C. $3\frac{1}{2}$ days in air.
1 per 1,000,000	No signs of poisoning except barely perceptible rim to some of prepared spots.	Slight to distinct superficial browning on prepared spots.	No signs of poisoning.	Superficial browning only.	No signs of poisoning.	No signs of poisoning.
1 per 100,000	Pale brown areas 2–4 mm. diameter to each prepared spot.	Pits 2–4 mm. diameter and 2–4 mm. deep.	Dark rims to each spot, 2 mm. diameter.	Pits 1–2 mm. diameter and $\frac{1}{2}$–1 mm. deep.	Faint brown rims to some but not all of prepared spots.	Slight to no superficial browning.
1 per 10,000	Dark brown to black areas 2–4 mm. diameter.	Same as with 1 per 100,000, but pits darker.	Dark rims to each prepared spot, 2–3 mm. diameter.	Pits 1–3 mm. diameter and $\frac{1}{2}$–$1\frac{1}{2}$ mm. deep.	Pale brown rims to all prepared spots, none exceeding 1 mm. diameter.	Superficial browning only.
1 per 1000	Dark brown to black areas, 2–5 mm. diameter.	Pits fused to a curved band of dead tissue 1cm. deep.	Black areas to each prepared spot 2–3 mm. diameter.	Pits 2–3 mm. diameter and 1–2 mm. deep.	Brown rims to all prepared spots none exceeding 1 mm. diameter.	Pits 1–2 mm. diameter and superficial to 1 mm. deep.

Prepared spots $1\frac{1}{2}$ cm. apart.

With Statesman apples therefore, the mercuric chloride ceases to exert any poisonous action at 0—1 deg. C. in a concentration of 1 per million, but continues to show a poisonous action at 25—26 deg. C. in a concentration of 1 in 10 millions. Comparing all the results, we may say that a fall of temperature of 25 deg. C. lowers the poisonous concentration 10 to 100 times.

Using copper sulphate and Yates' Pippin apples, the results were obtained as given in Table II.

In this case copper sulphate in a concentration of 1 in 10,000 exercised about the same poisonous action at 0—1 deg. C., as a concentration of 1 per 1,000,000 did at 28—30 deg. C., and the latter concentration exercised no poisonous action at all at the lower temperature. Under the conditions of the experiment therefore, copper sulphate was a hundred times as poisonous to the pulp cells of apples at 28—30 deg. C., as it was at 0—1 deg. C.

The influence of diffusion.

Temperature exercises a most important influence upon the rate of diffusion, and hence also upon the rate at which the poison in solution would diffuse to the prepared spots on the apples tested The rate at which the molecules of the dissolved substance reach the receptive surface is an important factor in determining the concentration at which a poisonous action can be exercised.

Thus in the case of Yates' Pippin apples floated on mercuric chloride solution at 15 deg. C. for three days, the poisonous limit was reached with a concentration of one gram in 10 million cubic centimetres of water. On the other hand, if the poisonous solution was allowed to trickle directly over three prepared spots, three times daily for three days, from a fine tube at a temperature of 14—15 deg. C., a slight poisonous action was still shown with a concentration of 1 gram in 1000,000,000 c.c of water.

Yates' Pippin, Mercuric chloride. 1 litre of solution run over three prepared spots, three times in three days. Temperature 14—15 deg. C. Trickled directly over prepared spots from fine tube.

1 per 100,000,000	-	No distinct signs of poisoning, but after 1 week in air, superficial browning with blacker rim to each prepared spot.
1 per 100,000,000,000	-	No signs of poisoning, and after one week in air no distinct signs of poisoning as compared with control treated with pure distilled water.

The same experiment as above was repeated, but the prepared spots were surrounded by a square centimetre paraffin cell 2—3 mm. deep through which solution trickled (see Pl. 3), 1 litre was used and trickled once daily through the cells and over three prepared spots for seven days.

1 per 100,000,000	Slight superficial browning	After 7 days in air superficial browning extending up to ½ mm. deep.
1 per 1,000,000,000	No distinct signs of poisoning	Faint to distinct superficial browning.
1 per 10,000,000,000	No signs of poisoning	No signs of poisoning.

Even superficial browning under the microscope can be seen to affect several successive layers of cells, one below the other, and even in small pits the number of cells affected soon runs up to the thousands. Since it must take a definite number of molecules even of mercuric chloride to completely poison each cell, there must be a limit to the dilution at which a perceptible poisonous action can be exercised.

A litre of a 1 per 10,000,000,000 solution contains $\frac{1}{10,000}$ of a milligram of mercuric chloride, representing some $\frac{10^{15}}{3}$ individual molecules, and assuming that 1000 cells are exposed to the absorption of poison, and that under the condition of the experiment at least $\frac{1}{300}$ to $\frac{1}{1000}$ of the molecules present are absorbed, then it would require at least 10^9 (one thousand million) molecules of mercuric chloride to poison a single pulp cell of an apple such as Yates' Pippin, which is one of the most resistant varieties. It is possible that a lesser number of molecules, say, 10 to 100 millions, might be able to arrest diastatic activity in a pulp cell without necessarily killing it.

To obtain some idea as to the influence of diffusion and of convection currents upon the conveyance of poison, comparative experiments were performed with apples on water, and on melted 10 per cent. gelatine allowed to set after adding poison. A preliminary test showed that ordinary gelatine contains traces of poisonous materials, but when well washed these are reduced to a mere trace. The apples must of course be clean, and the gelatine sterilised by two steam heatings, since fungi are able to develop on solutions poisonous to apples.

PREPARED YATES PIPPIN. ALL AT 12–13°C. FOR 1 WEEK IN 200 c.c. MERCURIC CHLORIDE.

	1 per 100,000.	1 per 1,000,000	1 per 10,000,000	No $HgCl_2$
In watery solution.	Pits 2-5 mm. diameter and 2-3 mm. deep.	Pits 2-3 mm. diameter and 1-3 mm. deep.	From faint superficial browning to pits 1 mm. diameter and depth.	No signs of poisoning.
In well washed and sterilized 10 % gelatine.	Slight superficial browning to pits 1 mm. diameter and depth.	From no signs of poisoning to slight superficial browning.	From no signs of poisoning to slight superficial browning.	From no signs of poisoning to slight superficial browning.

At first sight this experiment would seem to show that the conveyance of poisons to the prepared spots took place mainly by convection and mixing movements, although the cylinders containing liquid were not disturbed, and were kept free from vibrations, and kept at as uniform a temperature as possible. Mercuric chloride, however, coagulates gelatine in the presence of sodium chloride, and although no salt was present, the mercury evidently enters into combination with the gelatine, just as mercuric nitrate will precipitate gelatine by itself, so that the diffusion of the mercury is either stopped or very greatly retarded.

Hence to obtain a true diffusion comparison, agar and sulphuric acid were used. These do not enter into combination; the sulphuric acid diffuses as rapidly through agar as in stationary water, and the agar when well washed exercises no poisonous action on the pulp cells of prepared apples, while it has also the advantage of standing high temperatures better without liquefying.

Both the water cylinders and the agar cylinders were kept free from disturbance or vibration, the temperatures were kept as uniform as possible, the apples were picked Yates' Pippins all 15 centimetres diameter, and each with 15 prepared spots of 1 square millimetre area, equidistant around the periphery. The 1 per 10,000 solution contained 1.8 grams of pure concentrated sulphric acid to 9999 cubic centimetres of water, or to 9999 cc. of $1\frac{1}{2}$ per cent. agar solution; 150 cc. being used to each apple.

YATES PIPPIN AND SULPHURIC ACID.

Exposure and Temperature	Medium. Water.	Agar.	Total bulk of poisoned tissue	Rates of diffusion of H_2SO_4
3 days at 0°C–1°C	Superficial browning to pits 1–3 mm. diameter, and 1–2 mm. deep	Superficial browning to pits 1–2 mm. diameter and depth	0.002 c.c.	1 at 0°C
3 days at 10°C–11°C	Pits 2–5 mm. diameter and 2–3 mm. deep	Pits 1–3 mm. diameter and 1–2 mm. deep	0.003 c.c.	1.53 at 10°C.
3 days at 29°C–30°C	Pits partly confluent and 5–10 mm. deep	Pits partly confluent and 5–8 mm. deep	11.25 c.c.	3.83 at 29°C.

Hence it follows that in still water the poison reaches the prepared areas mainly by diffusion, and hence the poisonous action is only slightly decreased when the acid reaches the apple by diffusion alone through agar. In three days only a small portion of the acid present could reach the prepared areas by diffusion, so that the sensitivity of the pulp cells to sulphuric acid is fairly pronounced.

Furthermore, the comparison between the rates of diffusion and the bulk of poisoned tissue at different temperatures, shows clearly that the increased poisonous action at the higher temperatures is not merely a matter of diffusion, but is mainly due to the inherent sensitivity to poison being greater at the higher temperature.

The same is shown by the following test, in which three experiments were started at three preliminary temperatures (nine in all), and of each set of three, one was subsequently kept in air for four days at 0—1 deg. C., one at 10—11 deg. C., and one at 30 deg. C. During the preliminary immersal for three days, the apples were all in a 1 per million solution of mercuric chloride, so that the prepared spots in each set of three received the same amount of poison by diffusion, but during the subsequent exposures in air a consistently greater poisonous action was exercised at the higher temperatures.

YATES PIPPIN IN 1 PER MILLION $HgCl_2$

Preliminary treatment. Immersed for:	Subsequent treatment for 4 days in air. 0°C.–1°C.	10°C.–11°C.	30°C.
3 days at 0°C–1°C. From very faint superficial browning to no signs of poisoning	Superficial browning only	Distinct but superficial browning on each prepared spot	Pits 1-2 mm. diameter superficial to 1 mm. deep.

Preliminary treatment. Immersed for:	Subsequent treatment for 4 days in air. 0°C.-1°C.	10°C.-11°C.	30°C.
3 days at 10°C.-11°C. Faint to no superficial browning	From superficial browning to pits 1–2 mm. diameter and 1 mm. deep	Pit 1–2 mm. diameter and 1 mm. deep	Pits 1–3 mm. diameter and 1–2 mm. deep
3 days at 30°C. Brown spots 2–4 mm. diameter	Pits 3–5 mm. diameter and depth. Pit tissue pale brown, unshrivelled and containing some living plasmolysable cells	Pits 3–10 mm. diameter and 5–6 mm. deep, and broader below surface than on skin. Tissue brown and partly shrivelled	Pits 6–10 mm. diameter and 6–8 mm. depth, partly confluent. Tissue dark brown and shrivelled

The influence of temperature upon the sensitivity to poison is shown also by non-metallic poisons. Thus chloroform poured over the surface and then allowed to evaporate, produced brown pits over the surface below the lenticels, and with a watery solution the following results were obtained:—

Yates' Pippin. Chloroform. All showing no distinct superficial signs of poisoning after three days' immersal. Then all at room temperature for four days and examined.

Concentration.	Temperatures during Immersal. 30°C.	11°-12°C.	0°-1°C.
1 per 1000 c.c. (shaken up and excess allowed to slowly dissolve)	Pits superficial to 2 mm. diameter and depth.	Faint to no superficial poisoning.	No distinct signs of poisoning
1 per 10,000 c.c.	Pits superficial to 1 mm. deep.	No signs of poisoning.	No signs of poisoning
1 per 100,000 c.c.	No distinct signs of poisoning.	No signs of poisoning.	No signs of poisoning

Thus a solution of chloroform capable of exercising a distinct poisonous action at 30 deg. C., was non-poisonous at 0 to 1 deg. C. The presence of chloroform appeared to retard the browning of the affected cells, and Yates' Pippin appears to be 10 to 100 times as resistant to chloroform as Jonathans. (1st Paper, p. 402).

In another experiment normal apples were immersed in pure chloroform for short periods of time, and then kept in air for a week at the temperatures given.

Yates' Pippin. Normal surface. Soaked in chloroform, and then kept in air for 1 week at 14—15 deg. C., and at 0—1 deg. C. The calyx and stalk ends closed with paraffin.

Temperature	Time of Immersal in Chloroform. 10 seconds	100 seconds	1000 seconds
0°C–1°C.	Several shallow pits up to 5 mm. diameter and 1 mm. depth.	As before but pits slightly more numerous.	General browning over whole surface from ½ to 2 mm. deep.
14°C–15°C.	Several sunken pits up to 8 mm. diameter and 2 mm. total depth.	Numerous, larger and more deeply sunken pits up to 3 mm. depth, partly confluent.	General browning over whole surface from 2 to 8 mm. deep.

In this case the same amount of poison enters in each pair of apples subsequently kept at different temperatures, but the poisoning action is less at the lower than at the higher temperature.

The poisonous action of cell contents and cell products.

It has been suggested that the escape of the cell contents either by bursting or by exudation might cause the poisoning of neighbouring cells and the formation of bitter pit. Against this is the fact that young apples may be punctured without any result beyond the production of a superficial scar or depression when adult, but it seemed advisable to test the influence of the expressed sap and of different cell products on living pulp cells.

The influence of expressed sap on prepared apples.

The sap was rapidly expressed by pressure, and sound prepared apples floated in pure sap, in 20 cc. of sap to 80 water, and in 2 cc. of sap to 98 water for two days. They were immediately examined and also after five days in air, but no signs of poisoning was shown on any of the prepared spots, either using Yates' sap on Yates' apple, Sturmer sap on Sturmer apple, or Yates' sap on Sturmer apple, or Sturmer sap on Yates' apple.

After two days the liquid develops micro-organisms, and after three-four days' immersal, superficial browning may be shown. If the sap is boiled, sterilised vessels used, and the apples coated with paraffin before preparing for immersal, the expressed sap may remain practically sterile for three or four days, and no signs of poisoning were then shown in this time on any of the prepared spots. Evidently, therefore, the unaltered sap of apples is not poisonous to the pulp cells when applied to them externally. Apparently the ectoplasmic membrane of the pulp cells has the same diosmotic relationships to the vacuolar contents as the vacuolar

membrane has, so that a dissolved substance which is not poisonous inside the cell is not poisonous outside it. This is the more surprising because some of the cell contents when applied in pure form, are capable of exercising a poisonous action. Possibly this may be a question of ionization, of combination or of relative influence on the surface tension of the ectoplasmic membrane, and hence on diosmosis. The acidity of the sap of the ripe Yates' Pippin apples used was such that 2½ litres were equivalent to 10.6 grams of normal sodium carbonate. This is within the limit of dilution for the poisonous action of malic, citric and oxalic acids when used in pure form, and with exposures of a week's duration. It has already been shown that the poisonous action of a mixture of substances may be much less than when each is applied singly, and apparently it is this fact which explains partly at least, the practically non-poisonous character of freshly extracted apple sap to pulp cells when applied externally.

Alkali.—Since the protoplasm of the pulp cells is alkaline, although the sap is acid, the vacuolar membrane must be able to prevent the acid in the sap from entering the protoplasm, and we should expect to find the protoplasm more resistant to alkalis penetrating from outside than to acid. This has already been shown to be the case with ammonia and Jonathan apples, and it applies still more with caustic potash and the more resistant Yates' Pippin.

CAUSTIC POTASH. Strength of Solution.	PREPARED YATES PIPPIN IMMERSED FOR 5 DAYS AT 3–18°C. Result.
5 grams per 1000 c.c.	Dark brown pits to each prepared spot, 1–2 mm. diameter and depth.
1 gram per 1000 c.c.	Faint superficial browning to no signs of poisoning.
1 gram per 10,000 c.c.	No distinct signs of poisoning.
1 gram per 100,000 c.c.	No signs of poisoning.

With dilute solutions, however, the CO_2 produced by the respiring pulp cells would suffice to turn the diffusing KHO molecules into potassium carbonate, so that the alkaline action of caustic potash would be less evident than with equal dilutions of ammonia. In fact, with a 1 per 1000 dilution, the poisonous action may be largely due to the potassium ions, rather than to the hydroxyl ions.

Alcohol.—During the anaerobic respiration of apples small quantities of alcohol are produced, and are apparently to some extent transferred from the protoplasm which forms them into the cell

sap, since alcohol is one of those substances which are freely permeable to the protoplasmic membrane.

For the tests pure absolute alcohol was used, prepared Yates' Pippin apples being immersed for four days in the solution and examined after three days in air. The temperature averaged 14—16 deg. C.

1 c.c. of absolute alcohol per 10 c.c. of mixture. (100 c.c. of solution).	From superficial browning to pits 1–2 mm. diameter and depth.
1 c.c. of absolute alcohol per 100 c.c. of mixture. (1000 c.c. of solution).	From superficial browning to pits 1–2 mm. diameter and depth.
1 c.c. of absolute alcohol per 1000 c.c. of mixture. (1000 c.c. of solution).	No signs of poisoning.
1 c.c. of absolute alcohol per 10,000 c.c. of mixture. (1000 c.c. of solution).	No signs of poisoning.

Hence in its poisonous action on the pulp cells of apples, alcohol comes next to pure water, and is one of the least poisonous of all the substances tested.

Tannic acid or Gallo-tannic acid is present in the pulp both of ripe and unripe apples, and Mr. P. R. Scott's analyses give the amount as usually less than 0.1 gram per cent., and as being slightly more abundant in pitted than in normal apples.

Yates' Pippin prepared. After seven days' immersal at 13—16 deg. C., in tannic acid solutions in water.

1 gram per 100 c.c.	Brown pits 1–2 mm. diameter and depth.
1 gram per 1000 c.c.	Brown pits 0.5-1 mm. depth. 1-2 mm. diameter.
1 gram per 10,000 c.c.	No distinct signs of poisoning.
1 gram per 100,000 c.c.	No signs of poisoning.
1 gram per 1000,000 c.c.	No signs of poisoning.

Sturmer Pippin apples were sensitive to tannic acid in ten times greater dilution as compared with Yates' Pippin.

Tannic acid, therefore, comes next to alcohol in the feebleness of its poisonous action, and is less poisonous than many nutrient salts are when applied singly. It may safely be assumed therefore that the slight differences in the percentage of tannic acid supposed to exist between pitted and clean apples have no causative relationship with bitter pit.

The influence of mechanical injuries.

Stewart[1] noted that in a bruised fruit, the injured portion contained an abundance of starch, but not the uninjured portion. This of course would only be the case when the injury was caused at that period of development when the pulp cells are packed with starch. Bruises on quite young fruits, before the starch grains have been deposited, and on adult fruits after they have dissolved, do not show this peculiarity. Varcollier's[2] explanation is that in the bruised cells the tannin inhibits diastatic activity. McAlpine (l.c. page 21) states, "The death of the cells, in my opinion, is quite sufficient to account for the persistence of the starch in the bruised cells," being apparently unaware that diastase will act as well in a non-living medium as in a living cell. The explanation is merely that the escape of the sap from the bruised dead cells removes the medium into which the protoplasm excretes the sugar as it is formed, so that in the protoplasm of the dead cell the percentage of sugar inhibitory to further diastatic action is soon reached. Although diastase is a fairly stable compound when dry, in the moist cell it soon undergoes post-mortem decomposition, and hence the possibility of a post-mortem diastatic action is limited in time.

In any case the presence of starch grains in dead pulp cells, and their absence from the living pulp is not an infallible indication of bitter pit, and indeed this symptom only accompanies bitter pit when the defect begins to develop during the second or "starch" stage of the apple. If bitter pit arises during the early "proteid" stage of the apple or the adult "sugar" stage, the dead cells contain no more starch than the living ones. (1st paper, pp. 410-415.)

The relation of Bitter Pit to vascular tissue.

In those cases where bitter pit is due to poisonous substances absorbed through the roots, it would be natural to expect the dead tissue to be more or less closely associated with the conducting vascular bundles. This was actually observed by Wortmann (Landw. Jahrb. xxi. 1892, p. 663), but his generalisation is too sweeping. The vascular network in apples is comparatively small meshed, so that any large pit or spot must appear to be associated with a vascular bundle. Small pits, however, particularly when late in development, may be found which have no special connection with any one vascular bundle, and larger spots may be sometimes

1 Stewart, F.C., New York State Station, Bull. 164, 1899.

2 Varcollier, G., Compt. Rend. Acad. Sci., 141, p. 405, 1905.

found whose centres lie between two vascular bundles instead of on either.

The vascular system of the apple.

In a paper published by the Linnean Society of New South Wales, vol. xxxvi., 1912, pp. 613-656, D. McAlpine describes the vascular system of the apple (and pear), and apparently considered that its existence was unknown to Sachs and other botanists. As a matter of fact, the vascular systems of the apple and pear, as well as of fruits generally, were first described and figured by Nehemiah Grew in the year 1682 (Anatomy of Plants, Book IV., pp. 179-182, plates 65-67). Grew's description stands to the present day without modification, except that in the words "from which (the main branches) a few small fibres are dispersed without any order through the apple," "few" should be "numerous." Wortmann, in 1892, specially discussed the relation of the fine bundle endings and branches in the pulp to bitter pit, and Brooks (Bull. Torrey Botanical Club, xxxv. p. 423, 1908) represents the vascular system of the apple, and made dissections of the vascular network from frozen pulp. References to the vascular network in the apple are scattered throughout the literature dealing with the diseases of the apple. Hence it is difficult to understand why McAlpine (Report p. 36), describes the vascular network in the apple pulp as "this wonderful and hitherto unsuspected structure," and when McAlpine states (p. 28), "I venture to think that if these vessels, as well as the wonderful vascular network immediately beneath the skin, where the bitter pit originates had been recognised by Professor Ewart, he would have arrived at a very different conclusion," he makes both a misleading and an unwarranted statement.

A curious error also lies in the statement that "the vascular network is a strengthening system or skeleton," "with a fibrous portion to strengthen the delicate cells and prevent collapse." (p. 36). Fortunately for orchardists, this statement is untrue, since were it true apples would be difficult or impossible to eat raw, Cursory examination of the vascular bundles under the microscope shows the feeble thickening of the wood vessels which are conducting rather than skeletal structures, and the conspicuous absence of true skeletal elements such as wood fibres, sclerenchyma, collenchyma, etc. The rigidity of the apple is due to its distended pulp cells almost entirely, and when these collapse or lose water, the tissue becomes soft and flabby, although the rigidity of the vascular system is unaltered. The latter resembles a capillary blood system, rather than a skeletal framework.

McAlpine's theory of Bitter Pit.

This is in brief (p. 73) that when the supply of water is abundant the vascular network may not enlarge as rapidly as the pulp cells, "a mesh here and there will be left unfinished, the cells adjoining will not receive their regular supplies of nourishment through the regular channels, and collapse and death will ensue."

If the supply of water is deficient, "even if the mesh was completely formed, wherever the mesh of the network of vessels failed in conducting water, there the adjoining cells would collapse, and the entire patch shrivel and become brown."

McAlpine is apparently unaware of the fact that water can pass readily from one pulp cell to another, and that the starch grains usually present in abundance in bitter pit tissue, are carried to the cells through the vascular bundles in the form of sugar, showing that the bundles are functioning normally. It would be easy to obtain evidence of such interruption if it took place. No such evidence is brought forward, and none is to be obtained by the examination of bitter pit tissue. Furthermore, where the bitter pit tissue may form a continuous layer near the surface, as in some confluent forms of "crinkle," living tissue may occur outside the affected portion of the vascular network, from which on McAlpine's theory it should be cut off. His theory is based upon a series of assumptions, some of which are quite incorrect, and no experimental or anatomical evidence is brought forward to support it. The exciting cause demanded is either an excess or a deficiency of water, i.e., diametric opposites producing the same result.

Finally, I have shown that single pulp cells, or small groups of them, in immature bitter pits may retain their starch grains and remain living and turgid until the apple is fully adult, i.e., after the apple has been plucked and the flow of water and food materials through the vascular bundles has ceased. In such cases we are dealing with an inhibition of ferment action by an agency not strong enough to immediately kill the protoplasm, and the death of the starch-containing cells is simply hastened somewhat as compared with sugar-containing cells, possibly partly as the result of starvation. Under normal circumstances the sap of each cell is able to hold all the sugar produced from its starch, and since the protoplasm produces its own diastase, it is impossible to see how an interruption of the vascular system could prevent the conversion of the starch into sugar.

The poisoning theory of Bitter Pit.

A satisfactory theory in regard to a disease or defect should :—

(a) Coincide with all the facts.

(b) The suggested agency should be able to produce the disease or defect experimentally.

(c) The artificially and the naturally produced disease or defect should behave with approximate similarity under corresponding external conditions.

In regard to (a) the poisoning theory agrees with all that we know in regard to the action of ferments, to the sensitivity of the pulp cells to poison, and to the variation of their sensitivity with age, so that an amount of poison at first sufficient to arrest ferment activity would become generally toxic when the protoplasm reached a certain age. In regard to (b) it has been shown that every symptom of bitter pit, including external appearance, colour, character of dead cells and cell walls, and presence of starch grains can be produced by artificial poisoning. The last feature, on which so much stress is usually laid, is a general but not an unavoidable accompaniment of bitter pit. Any agency, including mechanical injury which kills the cells while packed with starch, will cause dead starch-containing tissue to be present in the apple pulp. If, however, the poisoning takes place before the starch has been deposited or after it has been dissolved; the dead bitter pit tissue will not contain any more starch than the living pulp.

In the early proteid stage of the apple, the cells are resistant to poison, and owing to the rapid cell multiplication and proteid growth, no concentration of absorbed traces of poison is possible. In the starch stage the cells are still resistant, and diastatic activity is the first function to be affected. Odd cells here and there are to be found in the pulp of most sound apples in which the starch grains have remained undissolved, but in which the poisoning progresses no further until the general pulp is approaching death. The reason why bitter pit is generally accompanied by cells packed with starch is because it is when proteid growth has ceased, that a concentration of absorbed traces of poison becomes possible, and because the sensitivity to poison increases from this stage onwards in the life of an apple.

It is in regard to the analytical evidence that the greatest difficulty of complete proof is to be expected. The tests carried out in conjunction with the Federal Analyst have shown that it is possible to produce artificial bitter pits with traces of poison so small as to be incapable of detection even by deli-

cate chemical analysis. McAlpine (p. 70 of Report) dismisses the poisoning theory of bitter pit in five lines as follows: "This theory is sufficiently disposed of by the analysis of pitted apples made by Mr. P. R. Scott, Chemist for Agriculture. A State Committee was appointed to collect pitted apples from unsprayed orchards, and on analysis, not the slightest trace could be found of either lead or arsenic, or any other mineral poison." Apart from the fact that the quantity of pitted apples from unsprayed orchards which this Committee, of which I was a member, was able to obtain was exceedingly small, and quite insufficient for an exhaustive examination of the delicacy needed, no attempt was made to detect mineral poisons in general. Mr. Scott practically confined his tests to the detection of arsenic. The only other test used was as follows, "Another portion of the dried material was incinerated at a low heat, and the ash dissolved in hydrochloric acid, and a current of sulphuretted hydrogen was passed through the solution. I did not obtain any coloration of liquid or precipitate by sulphuretted hydrogen." McAlpine is evidently unaware that this method would fail entirely to detect manganese, cobalt, nickel, zinc, aluminium, iron, or chromium. Further it would be entirely useless to attempt to detect lead, mercury, silver, gold ,or copper by this method when present in dilutions just within the toxic limit to the pulp cells of adult apples, without using very large quantities of material and special methods of extraction and mechanical or electrolytic concentration.

Only one experiment is given with a metallic poison—(Report p. 23)—and as an adult apple was used, in which the starch had all or practically all dissolved, little or no starch could be expected to be present in the dead tissue. A saturated solution of mercuric chloride in alcohol was used, which latter is able to kill the pulp cells by merely drawing water from them, and also interferes with the absorption of the mercuric chloride by the pulp. As the solution used had a concentration of 1,000,000,000 times above the toxic limit for Yates' Pippins, it is not surprising that some effects were produced.

In regard to the difficulty raised as to how poisons could be absorbed from the soil by the delicate root-hairs, and the statement that "the concentration within the cells must become more or less equalised with that without, before the plant can be properly nourished," (p. 27, of Report), every student of plant physiology knows that the latter statement is quite misleading. It is also well known that the roots of various plants can absorb traces of various mineral poisons, which may accumulate in special

parts or organs, particularly such as are ultimately thrown off (leaves, bark, fruits), without either the roots or the plant as a whole being affected. The following poisonous metals may be absorbed by various plants when grown on soils containing them: Zinc up to ·13 per cent. of ash, manganese up to 14 per cent., cobalt, nickel, mercury, silver, copper up to 1 per cent., lead, thallium, arsenic, titanium, etc. These absorbed poisons are either set aside in special parts or cells sacrificed as poison traps, or may not cause any injury at all if the plant has developed the power of precipitating them in an insoluble or innocuous form.

Actual tests with the roots of seedling apples showed (with sulphate of copper) a toxic limit lying between 1 in 100,000 and 1 in 500,000, although when transpiration is active the limit may be lowered, while when growing in garden soil seedlings may be watered with much higher concentrations without being appreciably affected. In the case of Yates' Pippin the toxic limit of the pulp cells (1 in 1,000,000), is not much lower than that of the roots, which may explain why this variety is practically immune to bitter pit, whereas in the varieties more sensitive to poisoning and to bitter pit, the ultimate toxic limit may be 100 times lower than for the roots, which allows an ample margin for differential poisoning. The pulp cells are end points where poisons may accumulate until a toxic limit is reached, and this toxic limit falls with increasing age or rising temperature. In addition waste and poisonous substances frequently tend to accumulate and concentrate in particular cells or groups of cells which are sacrificed for the benefit of the rest. Evidence has already been brought forward to show that this occurs in the apple.

Some of the experiments brought forward to show the absence of any connection between spraying and bitter pit are worthy of comment (Report p. 23). In a Deepdene orchard, where twelve trees were to have been cut down on account of bitter pit, these were reserved, and left unsprayed. As the result a total of 23¼ lbs. of fruit were formed, including twelve apples affected by bitter pit. So that, apparently, if the experiment indicates anything, it shows that the absence of one year's spraying reduced the bitter pit apples to one per tree!

At Burnley Gardens some fruits were enclosed in bags and others left exposed on an unsprayed tree of Annie Elizabeth. Of the apples enclosed in bags 55 per cent. were pitted, and of the exposed one 39 per cent. Calico bags were used, however, and as calico glazes sometimes contain zinc oxide and other metallic poisons, it would be interesting to know whether the bags were tested before use.

A very important point is to be noted in the Burnley Gardens records given as an appendix, namely, that varieties which in other places are given as immune, or nearly so, to bitter pit, appear to be very liable to it when grown in the Burnley orchard. Thus the degree of affection of certain varieties by bitter pit is as follows :—

	For Orchards generally.	For the Burnley Gardens.
Rome Beauty	Slight to very slight	Bad
Munroes Favorite	Very slight	Slight
London Pippin	Very slight	Bad
Dumelows Seedling	Slight	Bad
Gravenstein	Very slight	Slight
Statesman	Slight	Bad

Now for many years the Burnley Gardens have probably been the most thoroughly sprayed piece of ground in Victoria, and possibly in Australia. In France, it has been found that of the total copper applied as sprays during twenty years, one-half to two-thirds was retained by the soil, and could be recovered on analysis. At the Lausanne Viticultural Station (Switzerland) the surface foot of soil was found to have accumulated 3.5 parts of copper per 100,000 of soil, and in other vineyards as much as 11 parts per 100,000 were found. These figures are well within the limit of toxicity to the pulp cells of apples, even without any accumulation or absorption. It would be of interest to have an analysis of the Burnley orchard soil both now and after an interval of some years.

The British Board of Agriculture (Journal, vol. xix., p. 751, 1912) has recently carried out experiments to determine whether copper which is used in spraying or treating potatoes for various diseases, can be absorbed by the tubers, and to what extent. In the following table of the results obtained the numbers give the grains of copper found per lb. of the dry weight on analysis of the harvested tubers :—

	75 lbs. Strawsonite per acre.		75 lbs. Copper Sulphate per acre.		Untreated.	
	Peel.	Pulp.	Peel.	Pulp.	Peel.	Pulp.
Lancashire plots	1.44	0.10	0.16	0.08	0.12	0.07
Kew plots	0.08	0.045	0.094	0.051	—	—

The highest amounts in the pulp would not be appreciably greater than 1 part of copper per million of the dry weight, and since only living tubers would be harvested and tested, the cells of potatoes seem to be less sensitive to copper than the pulp cells of apples. The "untreated" soil must have contained a fair proportion of copper, and the lesser absorption from the Kew plots is probably

due to the soil containing more humus, which has a pronounced retentive and restraining action upon many mineral poisons, as compared with sandy soils.

The browning of the pulp cells.

According to McAlpine (Report p. 12), the browning of dead pulp tissue is due to a change in the cell walls, and "the gummy or mucilaginous substance which colours them brown is of a pectic character." As a matter of fact the brown colour is not in the cell wall, but in the protoplasm within it; it is not of a pectic character, and it is not either gummy or mucilaginous.

Lindret (Le Cidre, p. 150, 1893) concluded that an oxidase ferment was present which carries oxygen to the tannin of the cell and causes a production of dark coloured oxy-compounds which are precipitated upon the cell walls as a permanent dye. Behrens (Centralbl. f. Bakt. 2 abt. 1898, Bd. 4, S. 514) explained the brown colour as being due to the combination of a direct oxidation product of the tannic acid of the fruit, with the proteids of the cell. Before any definite conclusions can be made, however, it is necessary to know the distribution of the tannic acid in the cell, whether an oxidase ferment is present or necessary, whether a brown colouration can be produced in the absence of free oxygen, and what are the influences of different external conditions on the browning.

The distribution of the tannin in the cell.

Sap rapidly expressed by strong pressure from Statesman, Sturmer Pippin and Yates' apples, and filtered rapidly with the aid of a suction pump in 1-3 minutes, is quite colourless, and remains so on standing. It contains an iron-greening form of tannic acid.

The pressed pulp rapidly browns in air, and with $Fe\,Cl_3$ turns black. Hence one at least of the substances causing browning is not in the cell sap, but in the protoplasm or cell walls of the pulp cells. The black colour with $Fe\,Cl_3$ is produced rapidly with crushed cells, and is darker than before the sap was pressed out, but with living cells it only appears as the $Fe\,Cl_3$ penetrates the protoplasm and kills it. In freshly browned pulp, the colour is not in the cell wall, but in the protoplasm.

The residue of pulp cells on the filter in all cases slowly turns deep brown in air and turns dark with $Fe\,Cl_3$. At first it may contain still living pulp cells, and hence gives the $Fe\,Cl_3$ reaction more rapidly on boiling. Sap filtered from pressed pulp after

standing is distinctly brown, darkens with $Fe\ Cl_3$, and shows a faint pinkish shimmer against the brown with solid KCN. With an excess of alcohol and ether a flocculent brown precipitate is formed, soluble in water, and consisting largely of glucose, but blackening with $Fe\ Cl_3$ and showing brown with a pinkish shimmer with KCN.

If the slowly expressed sap is boiled before filtering, the filtrate remains almost colourless in air, but turns brown with NaHO, pink with KCN, disappearing and reappearing on shaking and standing, and green darkening to a distinct tannic acid reaction with $Fe\ Cl_3$. The residue on the filter paper contains less tannic acid. Apparently some of the tannic acid present in the slowly expressed sap is not present in the natural sap, but is taken up from the protoplasm after the latter has been killed. The non-browning of the sap from boiled pulp suggests the presence of an oxidase enzyme destroyed by heat.

J. af Klercker (Bihang till d. Svenska Vet. Ak. Handl. Bd. xiii. 111, 1888), concluded that tannin might either occur in the cell sap or in the protoplasm in the form of oil-like drops formed by the fusion of smaller ones, but that the actual substance of the protoplasm was always free from tannin. To test this apples peeled on one side (Plate V.) were immersed in solutions of ferric chloride, and of methyl blue and the coloured pulp examined after some days. With $Fe\ Cl_3$ the walls of the pulp cells remained practically colourless, and also the vacuole, whereas the protoplasmic contents turned brown. Under high powers round or occasionally oval vesicles of tannic acid stained brown with $Fe\ Cl_3$, and dark blue with methyl blue, could be distinguished readily in the protoplasm of the pulp cells. Apparently the $Fe\ Cl_3$ causes a slight contraction in size of the vacuoles, but in very many cells they are extremely abundant and conspicuous, and none of the pulp cells appear to be entirely free from them. If these tannic acid vacuoles exist in the living protoplasm, they would constitute a second osmotic system, each vacuole being surrounded by either a precipitation membrane or an organised plasmatic membrane, so that tannic acid could only escape from them when the osmotic membrane was destroyed and no new one formed.

The nature of the tannin material.

From its relative solubilities in alcohol and in ether, it may be concluded that it occurs in the form of tannic acid and not of gallic acid. Nevertheless, on boiling acid pulp some of the tannic acid

may be converted into gallic acid. There is no evidence to show that it is present as a glucoside. Since tannin vacuoles must have an osmotic pressure corresponding to that of the cell in which they lie, with their surface tension pressure added (possibly more than 1 atmosphere), the tannin in them must be more concentrated than in the cell-sap.

Exact estimates of the amount of tannin present in the cell are impossible; owing to the difficulty of extracting the whole of it. If any oxidation occurs the brown oxy-tannin combines very firmly with the protoplasm. Although traces of brown colouration may be imparted to the sap at first, once the browning is complete, it is not removed by 1 per cent. hydrochloric or sulphuric acids, darkens in stronger acid or in dilute sodium hydrate, and is not removed by ether, alcohol or peroxide of hydrogen. In a saturated solution of sulphurous acid the pulp rapidly becomes a lighter yellowish brown, but retains this colour even after two weeks without further fading. On washing, the pulp turned to the same shade of black with $Fe\ Cl^3$ as before. After three weeks in hydrogen peroxide the brown pulp was distinctly paler, and gave a fainter tannin reaction with $Fe\ Cl_3$.

Estimations of the tannic acid in a mixed solution are difficult to carry out accurately. In contact with granulated zinc or zinc foil tannic acid is slowly precipitated as a white tannate soluble in HCl, and a slow evolution of hydrogen is shown. With magnesium the evolution of gas is somewhat more rapid, but the white precipitate largely adheres to the magnesium, and becomes browned after a time. The first method, however, can be used even when the tannin is in an acid cell sap, and it appears to be capable of quantitative use, but it is so far not possible to devise a method which will determine the exact amounts of tannic acid originally present in the acid pulp, and apparent differences in the tannin contents of dead and living parts may be merely the result of unequal extraction.

The influence of oxygen on browning.

Preliminary trials showed that both peeled and unpeeled apples could stand repeated evacuations and replacement of an atmosphere of hydrogen or carbon dioxide for three days without the pulp cells being affected. Slices were then floated on glass boats on a one per 1000 solution of copper sulphate, and the air removed by repeated evacuation and replacement with hydrogen or carbon dioxide. They were then shaken into the liquid, and all gas drawn out by evacuation. After one day all the slices were quite unbrowned,

whereas slices floating on copper sulphate exposed to air were browned right through in this time. On admitting air the colourless slices rapidly browned on the surface, and more slowly in the deeper water-logged pulp.

Slices immersed in absolute alcohol slowly browned, especially along the veins, while slices in absolute alcohol under kerosene and in kerosene remained almost entirely colourless after one week, then slowly browning to some extent on exposure to air. In alcohol a little of the tannic acid slowly dissolves out.

The oxidase ferment.

The rapidly filtered sap from apples has no power of decomposing hydrogen peroxide, or of turning guiacum blue. The pounded pulp produces a slow evolution of oxygen gas, and turns guiacum blue, but the same is shown after the pulp has been soaked in ·1 per cent. solutions of mercuric chloride or copper sulphate, and then well washed. Boiled pulp causes a feeble decomposition of hydrogen peroxide, such as is produced by various organic materials or finely divided particles.

Pulp cells killed by immersal in 1 per cent and 0—1 per cent. solutions of soluble mercury or copper salts turn brown almost as readily as when killed by crushing. The same is shown when the pulp cells are killed by water saturated with chloroform or with chloroform vapour. In one experiment the presence of chloroform appeared to retard browning. Thus a band of skin 2 centimetres broad was removed around the equatorial peripheries of two apples, and one was immersed in (a) a 1 per 1000 solution of copper sulphate, the other in (b) a similar solution saturated with chloroform. In 1 week the brown tissue was 5—6 mm. deep in (b), and 8—9 mm. deep in (a). The central pulp, however, contained much air in (a), but was nearly fully water-logged in (b), apparently as the result of the influence of the chloroform on the surface tension of the air in the intercellular spaces. The different depths of browning were not therefore due to chloroform retarding the browning, but to aeration accelerating it. On exposure to air the central pulp of (b) browned inwards rapidly, but that of (a) more slowly.

If hydrogen peroxide is present tannic acid instead of turning brown with sodium hydrate, gives a light blue rapidly darkening, becoming dirty, and finally brown on standing. Since the pulp cells do not show this intermediate change, but turn directly brown with sodium hydrate, no hydroxyl appears to be present or to take part in the oxidation.

The influence of heat.

Slices of pulp dropped into boiling water until heated through remain colourless in the presence of oxygen, but the pulp gives strong and the colourless liquid faint reactions for tannic acid $FeCl_3$. KCN, etc.). After boiling filtered apple sap with dilute tannic acid, the liquid turned as black with Fe Cl_3 as before boiling. A section of pulp browned to half its depth by soaking in dilute tartaric acid and then boiled, did not develop any further brown colouration on exposure to air, but both the pale and the brown parts gave tannic acid reactions (Fe Cl_3. KCN). Boiled colourless pulp soaked in dilute sodium hydrate or ammonia and exposed to air slowly turns reddish brown by oxidation right through. Hence the absence of browning in boiled pulp is not due to any decomposition or complete removal of the tannic acid in the pulp cells.

If the pulp is slowly heated up to the lethal temperature in air it turns brown, and the same occurs in water, although the browning here is less pronounced, and the water accumulates small amounts of tannic acid.

Before we can understand these results it is necessary to consider the influence of acids on browning, since although solutions of tannic acid rapidly oxidise when alkali is added, they are not appreciably oxidised when directly exposed to air for a week or more either when pure or in the presence of glucose; cane sugar, or citric, tartaric or malic acids, or only acquire a very faint yellowish tinge on very prolonged exposure to air, which necessitates the use of sterilised spore-free solutions.

The influence of acids on the browning of the pulp cells.

When the pulp is immersed in any mineral or organic acid beyond a certain strength, but not strong enough to discolour the cell wall, the pulp cells do not turn brown, but remain colourless, although they are killed. At lower dilutions still sufficient to kill the pulp cells, browning takes place.

Sturmer Pippin Apples.	Concentrations at which pulp cells:— Turn dark brown.	Pale brown.	Remain colourless.
	p.c.	p.c.	p.c.
Sulphuric acid	0.01	0.1	1
Oxalic acid	0.1	0.5	1
Citric acid	1	4	7.5
Tartaric acid	1	5	10

The colourless pulp, however, after washing, gave black with $FeCl_3$, and brown with sodium hydrate, showing that the tannic acid had not been destroyed. Colourless acid pulp or colourless boiled pulp turned brown on soaking in dilute sodium hydrate or sodum carbonate or ammonia, but remained practically colourless after pounding up with precipitated chalk.

If the pulp browned by alkali is immediately replaced in acid it becomes slowly colourless again, but if kept for some time the brown colour is permanent, and is not removed by acid. Colourless pulp just neutralised with sodium hydrate, ammonia or precipitated chalk, darkens slightly on long exposure to air, but the colouration is feeble as compared with that produced in the presence of a slight excess of alkali.

Causes of browning. General conclusions.

The browning is due to the oxidation of tannic acid present in numerous minute vacuoles in the protoplasm of the pulp cells, and of an iron-greening tannin present in the cell-sap. The former appears to be gallotannic acid, and in the presence of free alkali its oxidation is not necessarily dependent upon the presence of any oxidase ferment. Oxidase action does not take place in acid media beyond a certain strength. When the protoplasm dies slowly in air the tannic acid in the presence of neutral or alkaline bases is oxidised. If killed rapidly by boiling, the oxidase enzyme is destroyed, and the acid in the cell sap penetrates the protoplasm and removes its alkalinity before the tannic acid has time to be oxidised. On the addition of alkali, oxidation takes place. When the pulp is killed by pounding or by pressure, brown oxidation products may appear in the sap. Tannic acid and the brown oxidation products combine rapidly with dying but uncoagulated protoplasm, and more slowly with coagulated protoplasm. The brown colour imparted to the protoplasm is then very permanent, and is not removed by acid.

When living pulp cells are placed in poisonous solutions which destroy oxidases, the protoplasm is killed, and the tannic acid in the protoplasmic vacuoles is oxidised in the presence of its alkali or alkaline bases and of oxygen before the vacuolar membrane loses its osmotic properties and allows the acid of the sap to penetrate the protoplasm and remove its alkalinity. If the poison used is a free acid above a certain concentration, dependent upon its rate of diffusion, combining avidity and ionisation, the alkalinity of the protoplasm is neutralised as it is killed, and no browning takes place. The tannic acid is, how-

ever, still present in combination with the coagulated proteid, and will give the characteristic reactions and turn brown on adding alkali.

If all the oxygen is removed, the cells can be killed by poison without turning brown, and if the acid sap has been given time to penetrate the protoplasm completely no browning takes place on admitting air until alkali is added.

When slices of pulp are dropped into absolute alcohol, which destroys the oxidase, they remain practically colourless, because the rapid penetration of the alcohol destroys the vacuolar membrane and allows the alkalinity of the protoplasm to be neutralised by the acid sap before the tannin has time to oxidise. Along the veins, however, where there is little or no acid sap, browning may take place, although the oxidase is destroyed by the alcohol.

When an apple is cut with a sharp razor the cut surface remains quite pale, whereas when scraped or cut with a blunt knife it turns rapidly brown.

If the cut or scraped surface of the pulp is moistened with hydrochloric acid of acidity somewhat greater than that of the cell sap (0.5 to 1 per cent.), which diffuses rapidly through the ectoplasmic membrane, the cut or bruised surface remains quite pale.

The relative rates of death, of penetration of acid, and of escape of sap appear to be factors in producing these differences, but the matter needs further investigation.

The Anaerobiosis of the Apple.

McAlpine (Report p. 42) states that when the supply of free oxygen is cut off apples and pears can still live for months. No experiments or references are given in support of the statement. It has long been known that apples will live for a long time in a confined space, but then they contain a large amount of air to begin with, and their respiration is not very active, particularly at low temperatures.

Yates' Pippin apples were placed in an air-tight receiver, exhausted, filled with pure CO_2, again exhausted, and the process repeated several times daily for the first three days, and then every third day. The temperature averaged 14—18 deg. C., reaching 20 deg. C. twice during the longest period of exposure. After two weeks in CO_2 all were sound and living, but after one week in air slight decay was shown at some points near the surface.

After three weeks in CO_2, the pulp was collapsed, and dead on the surface at some points. The fact that the dead tissue was

slightly browned would show that a trace of free oxygen was still present in the pulp.

After four weeks the apples were collapsed, and the surface wrinkled for the most part, the pulp dead and slightly browned, becoming very dark on exposure to air. Portions of living pulp averaging one-fourth of the bulk in some parts extended from the surface to the core.

After six weeks in CO_2, all were dead, the first portions dying being distinctly brown, the later portions to die being practically uncoloured until air was admitted.

Evidently the air is only slowly removed from an unpeeled apple in an atmosphere of carbon dioxide. Using hydrogen, similar results were obtained, but death took place in four to five weeks, probably owing to the more rapidly diffusing hydrogen removing the air from the apple more rapidly.

Apparently a Yates' apple is not capable of more than a month's strict anaerobiosis, and carbon dioxide has no poisonous action on the pulp cells, acting simply by replacing air.

Experiments were also tried on the effects of covering the skin of apples with comparatively impermeable films, and of immersing them in liquids in which oxygen is more or less soluble than it is in water. Of these the results obtained under kerosene and with gelatine films are of most interest.

Apples immersed in kerosene.

Peeled apples under a depth of two to four inches of kerosene remained a pale greenish colour for fourteen days, and the pulp cells were turgid and living. In three weeks they turned soft, and slowly acquired a brownish colour, duller and not so dark as in air. From the surfaces small plasmodium-like masses of granular whitish material exuded, which later appeared to grow over the whole surface as a white felt-like moss. This consisted of very fine, much-branched threads, with no spores and few or no transverse partitions. The appearance was as though a granular plasmodium had turned into a filamentous mycelium.

Slices of raw potato infected with the mycelium developed under kerosene white sunken patches at each point of infection, ramifying at first in the substratum, but later more on the surface, the threads being somewhat coarser, and more septate than on the apple, possibly as the result of better nourishment. Over the uninfected surface and on uninfected slices, small whitish granular plasmodium-like exudates appeared, turning later brownish. These

are merely soluble exudates from the cell precipitated in contact with the kerosene.

Mycelium infected slices of potato and apple in air developed blue patches at each point of infection and characteristic Penicillium sporophores. The same formed slowly on pieces of the original felt-covered apples when kept in moist air. Penicillium is hence able to slowly develop a vegetative mycelium when immersed under a depth of two to four inches of kerosene. It appears also that neither the living ectoplasmic membrane of the pulp cells of apples or that of Penicillium is permeable to kerosene. Chudjakow (Lafar Technische Mykologie, 1, 315) has shown that Penicillium can grow at a pressure of 10 mm. when well nourished (glucose, etc.), and oxygen is about 5 times more soluble in kerosene than in water.

The influence of gelatine skins on apples.

Sound Yates' Pippins which had been kept in cool storage from March 1 until September 1 were exposed to air on a laboratory table, the temperature ranging from 13 deg. C. to 33 deg. C. during the following six months. One half were untreated, the others were momentarily immersed in melted 10 per cent. gelatine at 40 deg. C., and hung up by the stalks to drain. The gelatine soon dried, forming a very thin skin on the surface, and giving the apples a very glossy bright colour. In spite of the blocking of the breathing pores, sufficient air diffuses in to prevent asphyxiation. After two months the untreated apples were darker coloured, more or less pitted, soft or wrinkled, and in two to three months had begun to rot or were completely rotted, in every case the rotted pulp containing fungal hyphae. The gelatined apples after three months were brightly coloured and though slightly soft on the surface were smooth or only slightly wrinkled. In the latter case the gelatine films separated slightly from the skin at one or two points, but no signs of decay were shown. After five months the gelatined apples were still sound, and brightly coloured, but slightly soft or wrinkled in parts, whereas the untreated apples had contracted to shrivelled brown masses. After six months the gelatined apples were still of a sound bright colour, and the flesh of a good flavour, but not quite firm. As the room was a very dry one, the conditions as regards the loss of water were, however, very severe, and the apples had already been six months in cool storage. This simple method of gelatining the skin seems suitable for preparing apples for exhibition or for preserving small lots of valuable apples without the necessity of cool storage. The apples must of course be kept

dry, and should not be in contact, or if so, should be wrapped in tissue paper, and a free circulation of dry air allowed between them. Whether the method would be of any use for extensive storage could only be told by actual trial.[1] The gelatining does not at first affect the flavour of the apples, and if properly done the gelatine skin is hardly noticed when the apple is peeled.

The rotting of apples in storage appears to be almost entirely due to the development of fungal hyphae in the pulp, the spores entering from the surface through the breathing pores of the skin. Gelatining the apple would prevent any entry of spores and remove this source of decay, if no spores had already gained entry. Apart from this source of death, there is no reason why sound apples should not gradually shrivel when kept without any actual rotting occurring. It has already been stated in Germany that apples keep much better if the surface is sterilised by washing in formalin. Wrapping in tissue paper would then prevent the entry of fresh spores from outside.

The drying and contraction of Bitter Pit tissue.

This is the natural result of the fact that the plasmatic membranes on death lose their power of preventing the escape of the dissolved materials present in the vacuole. As these diffuse outwards the water follows them, and is drawn into those still living cells whose osmotic pressure is not fully satisfied. This is aided by the elastic contraction of the previously distended cell walls, and their ultimate complete collapse is hastened by the loss of water by evaporation. With artificial poisoning sunken pits only develop when the poisoning is localised. When the whole surface is browned it remains smooth until much moisture has been lost. The stretched epidermis contracts at first *pari passu* with the collapse of the superficial pulp cells, and it is only when the contraction is excessive that either cracks appear or that the epidermis becomes wrinkled so as to retain the same total surface area.

In the following experiment peeled Yates' Pippins of exactly equal weight (60 grams.) were floated on 250 cc. of each liquid and weighed daily. In the two poisonous solutions the total weights of mercuric chloride present were 0.20 and 0.125 of a gram respectively, amounts too small to affect the weights appreciably by absorption.

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1 Mr. Schoubridge informs me that unpublished experiments have shown that in time the flavour is sufficiently affected to lower the saleable quality particularly for export. but no data are available of the varieties tested or of the conditions under which the tests were made.

	Increase of Weight. After 1 day.	During 2nd day.	During 3rd day.	Condition.
	p.c	p.c.	p.c.	
Water	12.8	4.9	4.5	Brown on surface and water-logged to 11mm. depth.
$HgCl_2$. 1 per 10,000	13.9	6.9	2.9	Browned 11mm. deep and water-logged 12m.m. deep.
$HgCl_2$. 1 per 2000	15.1	6.9	4.6	Browned to depth of 14m.m. and water-logged 15mm. deep.

On the third day the apple in the 1 per 2000 solution sank, that in 1 per 10,000 was just afloat, and the one in water, though still afloat, was floating lower than before. The increase of weight results mainly from the water filling the air spaces in the pulp, and the collapse or contraction of the cells killed by poison enlarges the air spaces, and hence accelerates the entry of water.

The distribution of water and ash in apples.

Zschokke (Landw. Jahrb. d. Schweiz, 11, p. 192, 1897), showed that in transpiring apples there might be a difference of from ½ to 1 per cent. in the amount of water in the basal and distal portions of the fruit. This is the natural result of the greater abundance of breathing pores, through which water vapour escapes, on the calyx half of the apple. McAlpine (Report p. 73) gives similar data for Annie Elizabeth apples.

	Freshly Plucked. Top.	Middle.	Bottom.	After 8 days. Top.	Middle.	Bottom.
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.
Clean	85.50	86.23	86.12	85.68	86.74	86.92
Pitted	85.49	87.04	87.58	86.13	86.51	86.17

Hence the average percentage of moisture in the clean, freshly-plucked apples was 85.95 per cent., and after eight days in air was 86.45 per cent., the numbers for the pitted apples being 86.7 per cent., and 86.27 per cent. respectively. Apparently the percentage of moisture increased in the clean apples after eight days in air, and decreased in the pitted apples, a remarkable result, if not due to faulty methods or the use of unequal material. In any case it is evident that variations of ½ to 1 per cent. of water can be of no importance in regard to bitter pit, for much greater variations are shown by growing and adult apples, and the weight of a fresh apple can be reduced by drying by 5 to 10 per cent. without the pulp cells being injured.

Much greater importance is to be attached to variations in the percentage of ash, although in the case of a strong metallic poison an apple might be completely killed without its precentage of ash being appreciably increased. Mr. P. R. Scott's analyses, however, seem to show that bitter pit apples and pears contain a greater percentage of ash than usual. (Report pp. 46, 47.)

	Percentages of Ash. Sound.	Pitted.
Josephine Pears	0.38	0.43
Stone Pippin Apples	0.42	0.48
Lord Wolseley Apples	0 271	0.352

The pitted fruits only contained 1 to 2 per cent. less moisture than the clean ones, so that the bitter pit tissue must have been in an early sappy stage, and the ash which represents materials drawn from the soil does actually appear to be more abundant in bitter pit tissue or in pitted fruits. No analyses of the ash are given, unfortunately, so that it is uncertain whether the increased ash contains unusual or poisonous constituents.

Effect of manuring on Bitter Pit.

The results of a variety of tests with different manures are given in the Bitter Pit Report in great detail (pp. 80-91). In the Box Hill orchard the percentage of bitter pit in the two check plots was 1.3 and 4.5. The percentages on the manured plots were all less than the difference between these two. In the Bathurst plots the averages for the two unmanured plots were 1.42 and 3.00, and this was a greater range of variation than was shown by any of the manured plots. In the Blackwood orchards the number of pitted apples varied from 1 to 5, and the number of apples from the three controls varied from 1 to 56. None of these tests therefore show anything, the differences observed being of the field variation character.

Effect of pruning on Bitter Pit.

In regard to the results given with pruning (Report p. 92, 98), a similar criticism holds. In the Burnley results, with leader pruning, the bitter pit apples varied from 2 to 21, a greater range of variation than between the different modes of pruning, showing that the numbers given are meaningless as regards the effects of pruning. In the Deepdene orchard the bitter pit apples from unsprayed trees pruned in four different ways totalled only 12, with a variation of 1 to 5. The Bathurst tests are most satisfac-

tory, and in spite of the high range of variation (0.54 to 8.41) seem to indicate that medium pruning produces the largest amount of bitter pit, and no pruning the least, whilst hard pruning is intermediate. Nevertheless on page 81 of the Report medium pruning is recommended as one means of reducing bitter pit. Medium pruning tends to concentrate the sap on the fruits, and with it any poisonous ingredients absorbed, while hard pruning tends towards new wood formation, and so diverts some of the sap from the fruits.

The interesting experiments with different stocks carried out by Mr. Quinn are not yet far enough advanced to enable any conclusions to be made, but grafting is not likely to affect the resistance of the pulp cells of the grafted scions to poisons.

The influence of cool storage on Bitter Pit.

Since the resistance of the pulp cells to poison is greatly increased at low temperatures, it is only to be expected that in cool storage the development of bitter pit should be retarded or even stopped, when only minimal amounts of poison are present. If the starch grains were undissolved, the low temperature would prevent or delay the last stage of complete poisoning and turning brown. If the amount of poison present is relatively large, brown spots may still appear in cool storage, but the amount will be reduced. (Report pp. 103, 105.) The influence of cool storage is mainly confined to preventing or delaying the onset of the later stages of poisoning, such as death and collapse of the cells, the turning brown and acquiring a more or less distinct bitter taste. It is, however, precisely these changes which render affected apples unsaleable. An apple in the incipient stages of bitter pit, though a little less sweet, will be as edible as one not affected at all, and the point may be once again emphasised that an apple may be completely poisoned with various metallic poisons and yet contain insufficient poison to produce any poisoning symptoms or effects when eaten.

Conclusions.

The evidence in favour of the poisoning theory of bitter pit brought forward in the present and previous paper, may be briefly recapitulated as follows:—

It is possible by applying poison during the starch stage of an apple to reproduce artificially every symptom of bitter pit. The diastase ferment which is responsible for the normal solution of

the starch grains is present during at least the early stages of bitter pit. The starch grains are normal and capable of solution. The only agency capable of preventing their solution in localised living cells under the conditions existing is a poison.

The most resistant apple (Yates' Pippin) to poison is also the most resistant to bitter pit.

At low temperatures the resistance to poison is increased ten to a hundred times (0 deg. C. as compared with 30 deg. C.). In cool storage the resistance to the full development of bitter pit is similarly increased.

The poisoning theory is in accordance with all that is known in regard to the sensitivity of the pulp cells to poisons, to their diminishing resistance with increasing age, and to the changes which take place in the cell. The increased percentage of ash in bitter tissue is evidence pointing in the same direction.

Dr. White, in bitter pit apples from an orchard heavily sprayed with arsenate of lead, was able to detect the presence of traces of lead. Against this is the fact that the State Analyst was unable to detect arsenic in a limited number of bitter pit apples from four orchards certified to have been unsprayed. Any poison is, however, capable of producing bitter pit symptoms, and the results obtained by the Federal Analyst show that it is possible to poison the pulp cells of apples by traces of poison so minute as to be incapable of detection even by delicate chemical analysis.

No other theory of bitter pit will stand critical examination or scientific testing. Mr. McAlpine's vascular interruption theory is unsupported by observation or experiment, and is negatived by the fact that during the early stages of bitter pit the vascular connections are normal. The cracks appearing in the tissue form during the later stages, they are not always present, and are the result and not the cause of the death and contraction of the pulp cells. In addition, the starch grains of bitter pit tissue and its ash constituents are carried to it by materials conveyed along the vascular bundles, and since the percentage of ash in bitter pit tissue is higher than in healthy pulp, the conducting channels must have been functioning more actively if anything than usual. The accumulation of absorbed poisons at certain points causes these cells to be sacrificed to maintain life in the rest.

The browning of apple pulp is due to the oxidation of tannic acid. Apparently gallotannic acid occurs in numerous minute rounded vacuoles in the protoplasm of the pulp cells in addition to the iron-greening tannin of the cell-sap. If so, the plasmatic membranes of these vacuoles must be impermeable to alkali or oxygen, or both when

living. The vacuolar membrance is impermeable to the acids of the cell sap. When a metallic poison which destroys oxidase is applied externally, alkali and oxygen may come into contact with the tannic acid and produce browning, before the vacuolar membrane becomes permeable to the acid of the cell sap. When the cells are killed by boiling oxidase is destroyed, and the vacuolar membrane allows acid to escape immediately, and neutralise the alkalinity of the protoplasm, so that the pulp remains colourless until alkali is added. When the cells are placed in toxic but very dilute sulphuric acid, browning occurs before the alkalinity of the protoplasm is removed, or before the oxidase is destroyed. With stronger acid solutions the oxidase is destroyed or the alkalinity is removed before the tannic acid has time to oxidise, and no browning takes place. The brown oxidation products rapidly unite with the proteids of the cell. and the colour is then very permanent. Carbon dioxide and unaltered cell sap are non-poisonous to the pulp cells. Tannic acid is less poisonous than any other acid tried, and alcohol is less poisonous than lime water.

Yates' apples do not appear to be capable of more than a month's strict anaerobiosis in hydrogen or carbon dioxide at room temperature. In a cool chamber the period would probably be prolonged Apples can be preserved to a remarkable extent by coating them with a gelatine skin. Peeled apples will remain living for a fortnight longer under kerosene, and the fungus Pencillium will grow upon them and upon potato slices submerged in kerosene.

DESCRIPTION OF PLATES.

Plate III.—Localised poisoning, with 1 per 1,000,000,000 of mercuric chloride.

IV.—Fig. 1. Portion of vascular system of apple x 12½.
Fig. 2. Portion of vascular system of apple x 29.
Fig. 3. Endings of vascular bundles in apple pulp x 22.

V.—Fig. 1. Apples peeled on one side and blackened with ferric chloride.
Fig. 2. Portions of blackened pulp cells x 10, showing tannic acid vacuoles.
Fig. 3. Tannic Acid vacuoles in protoplasm of pulp cells stained with ferric chloride x 320.
Fig. 4. Do., stained with methyl blue x 400.

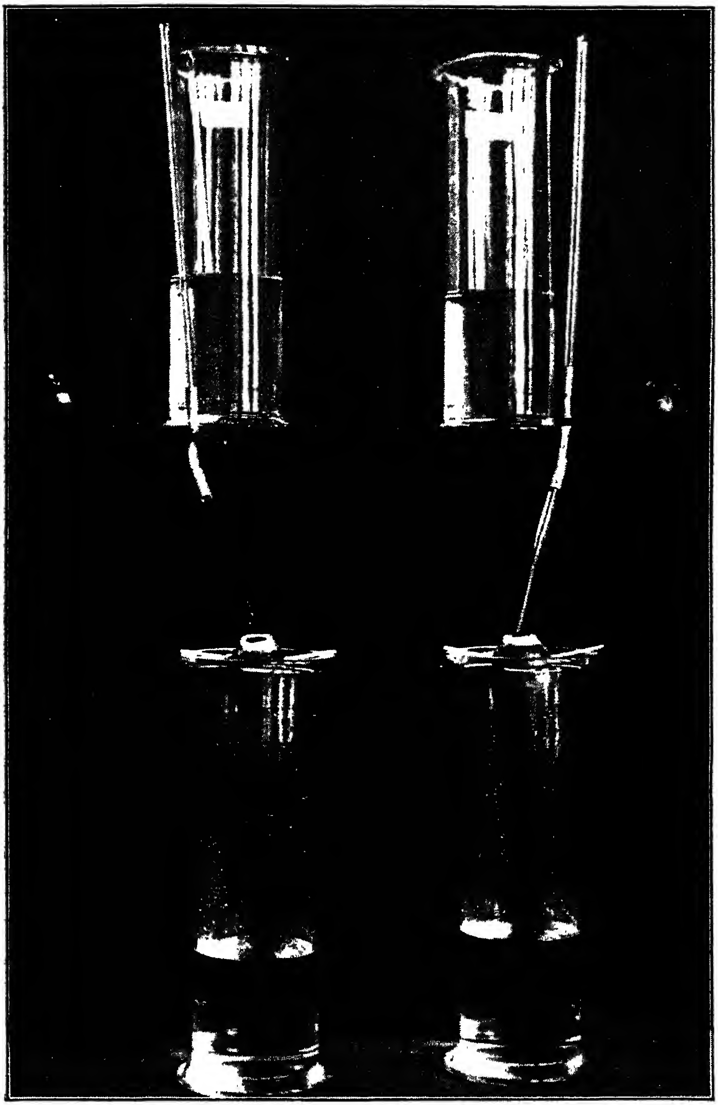

Fig 1.

Fig 2.

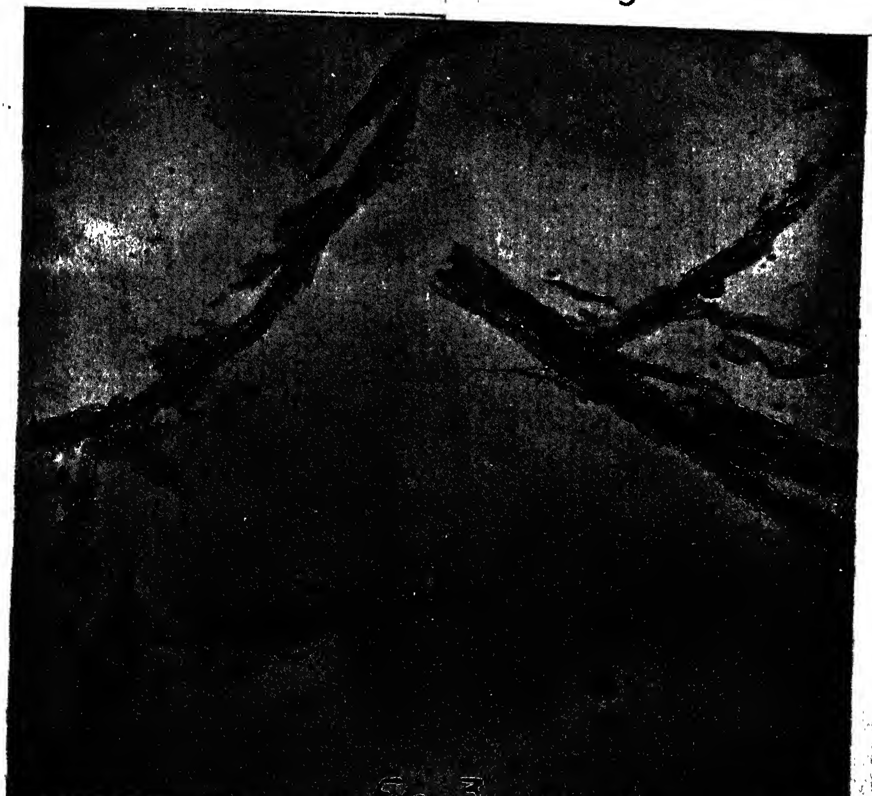

Fig. 3

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

[PROC. ROY. SOC. VICTORIA, 26 (N S), PT. I, 1913]

ART. III.—*On the Age and Physiographic Relations of the Older Basalts of Greensborough and Kangaroo Ground, and of certain Basalts at Bundoora and Ivanhoe.*

BY J. T. JUTSON

(Geological Survey of Western Australia)

[Read 10th April, 1913].

Introduction and Previous Literature.

The Kainozoic basalts of Victoria have hitherto been divided into two main series, the Older Basalt and the Newer Basalt. The former is represented by the isolated patches lying mainly to the east of Melbourne, and the latter by the great volcanic plains to the west of the same city.

Whilst, however, these two principal series have been recognised, some suggestions have from time to time been made that there is an intermediate series. Thus, as pointed out by Mr. T. S. Hart in his "Volcanic Rocks of the Melbourne District,"[1] the older volcanic rocks are divided into two groups on the Geological Survey Maps—viz., Older Volcanic and Lower New Volcanic. Mr. Hart shows that the largest area of the Older Basalts, near Melbourne, lies along and to the east of the Saltwater River, and reaches down to Melbourne, reappearing beyond the Yarra at Emerald Hill; and that the greater part of it is coloured and lettered on the maps as Older Volcanic, the south-eastern end is coloured and lettered as Lower New Volcanic, and the middle is coloured Lower New Volcanic and lettered Older Volcanic. Mr. Hart concludes that from the sections round Melbourne there is a series of older volcanic rocks, overlaid by marine Tertiaries, and perhaps a second series before the newer volcanic. Mr. Hart also discusses the age of the Greensborough older series of basalts, as will be shown later.

Messrs. Hall and Pritchard in their paper on the Tertiaries in the neighbourhood of Melbourne[2] also point out (p. 189) that the volcanic rock at South Melbourne and West Melbourne is coloured on the Geological Survey Quarter Sheets as Lower Volcanic—i.e., Lower Newer Volcanic—and is so lettered except on Quarter Sheet

1 Vict. Nat., vol xi. (1894), p. 75.
2 Proc. Roy. Soc. Victoria, vol ix. (N.S.), 1896, pp 187-229, pl. 8

I.N.W., where the lettering is V.O.—i.e., Older Volcanic; but that Mr. Brough Smyth showed[1] that these rocks were of the same age as those on the west of the Moonee Ponds Creek, and are all Older Volcanic. Messrs. Hall and Pritchard also mention that Brough Smyth's classification was adopted by Mr. R. A. F. Murray, in his book on the Geology and Physical Geography of Victoria (1887).

Dr. Hall,[2] in treating in a popular way of the basalts near Melbourne, mentions that there were two distinct outpourings of lava in Southern Victoria, that there may have been, and apparently were, more, but two are clearly distinguished about Melbourne (these two being the basalt below the tertiary sediments—the typical Older Basalt at Flemington, etc.—and the Newer Basalt of the plains).

Thus we see that both Mr. Hart and Dr. Hall have clearly recognised the possibility of a period of basalt eruption in addition to those in which the typical Older and Newer Basalts were brought to the surface.

The present paper treats only of the small areas of Older Basalt at Greensborough and Kangaroo Ground, of the basalt forming the cap of Mt. Cooper, near Bundoora, and of a small patch of high-level basalt at Ivanhoe.

The Kangaroo Ground basalt was first mapped by Selwyn[3] on a small scale, and was classed by him with the basalt at Lilydale, Hoddle's Creek, Berwick, and other localities, under the heading of "Bassalt, Amygdaloid Porphyry and Old Eruptive Rocks."

Murray[4] places the Kangaroo Ground basalt in the Older Volcanic rocks.

The Victorian Geological Survey in 1895[5] (?) partly re-mapped the area, and marked the rock as "Volcanic," apparently overlying "Miocene" sediments.

The present writer has also mapped part of the same area, and on the map, for convenience, has adopted the conventional Older Basalt. In his paper on the physiography of the Yarra basin,[6] the basalt at Kangaroo Ground is regarded as a monadnock on the Nillumbik Peneplain, but it was there stated (p. 504) that this

1 "Notes on the Rock Formations of Victoria," Catalogue of the London International Exhibition, Melbourne, 1872-3, p. 16.

2 "Victorian Hill and Dale," Melbourne, 1909, p. 62.

3 "The Basin of the River Yarra and part of the Northern, North-Eastern and Eastern Drainage of Westernport Bay," with plans and sections. Notes and Proc. Leg. Council, Victoria, 1855-6, vol. ii., part 1.

4 The Geology and Physical Geography of Victoria. Melbourne; by authority, 1887, pp. 108 and 111.

5 Geological Survey of part of the Parish of Nillumbik.

6 Proc. Roy. Soc. Victoria, vol. xxiii. (new series), pt., ii., 1911 (1910).

basalt and that capping the hills at Greensborough would be dealt with in another paper.

The Older Basalt at Greensborough, on each side of the Plenty River, was mapped by Aplin[1] in 1868, and on the map it is coloured as Lower Volcanic, Pliocene—i.e., Lower New Volcanic of the Survey. Note 3 on this map is to the effect that from the position the sands, grits and conglomerates [Kainozoic] occupy with regard to the adjacent basaltic outliers—[i.e., the basalt now being discussed]—there is good reason for believing that the former pass beneath the latter, but that there are no wells or shafts to prove this. Note 6 on the same map states that the basaltic outliers in general appearance bear great resemblance to the larger ones further east, known as the Kangaroo Ground, but are not underlaid by the peculiar siliceous rock found under the latter.

Mr. Hart in his paper already cited stated that these basaltic rocks were considered to be Lower New Volcanic, as they seemed to overlie the Tertiaries (though this was not certain), and had been deeply eroded before the lava streams [of the Newer Basalt] covered the plains, and that they were remnants of a once more widespread lava stream.[2]

The basalt which forms the cap of Mount Cooper was mapped by Aplin in 1868 as Upper Volcanic (Pliocene), and as being continuous with the lower level widespread flows to the west, which belong to the Newer Basalt period. Note 5 on the map states that the basalt [i.e., the isolated patches near Greensborough already referred to] to the north-west and east of Mount Cooper, is of older date than that of the Mount, which is a volcanic hill. It is necessary to assume that Mt. Cooper is a volcanic vent, to explain the difference in level between the flows to the west and the basalt capping the hill. Several outliers of high-level basalt to the east of the main road near Mt. Cooper are also included in the Newer Basalt. These have not been examined by the writer.

The high-level basalt at Ivanhoe is merely indicated on Quarter Sheet I.N.E. (surveyed under the direction of Selwyn and published in 1860) as " basalt boulders " near " blocks of hard siliceous conglomerate " on the old main road between Ivanhoe and Heidelberg.

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1 Q.S. 2 S.E.

2 It is interesting to note that Mr. Brough Smyth ("The Goldfields and Mineral Districts of Victoria;" Melbourne, 1869, p. 16) states that a little north-west of Morang, a very small patch of Older Basalt is seen in the centre of a lttle island of Palaeozoic strata, which is surrounded on every side by the Newer Volcanic rocks. This outcrop has not been seen by the writer.

3 Q.S. 2 S.E.

The Greensborough Older Basalts.

These rocks form a series of small isolated patches on the tops of the hills on each side of the Plenty River in the neighbourhood of Greensborough and Janefield. They were mapped in the early days of the Victorian Geological Survey, and were re-examined by the writer whilst mapping the country to the east of the Plenty River prior to his departure in 1911 for Western Australia.[1] Associated with them are the Kainozoic gravels and sands shown on the Survey Quarter-Sheet. As already noticed, Aplin and Hart doubt whether the basalts rest upon the sediments. At the time of my examination of the country, no sections were available showing the actual relations, but from an exhaustive examination I have no doubt that the basalt overlies the sediments.[2] This opinion is based upon the relative positions of the two rocks throughout the area, but it is supported by the fact that no basalt pebbles in the sediments have been discovered by the writer. If the basalt were the older, we should certainly expect some of its pebbles to be included in the sediments.

If the relations between the rocks be as stated, then the age of these Kainozoic sediments becomes an important question as regards the correlation of the basalt, and merits some attention.

Generally similar sedimentary rocks are found to the south in isolated patches, forming as a rule the caps of hills, such as at Heidelberg, Preston, Northcote, Studley Park and Royal Park. These appear to pass into the more or less continuous sheets to the south-east of Melbourne, and there can be little doubt that the whole of these rocks were originally unbroken on the Nilumbik Peneplain,[3] the more northern areas probably being of freshwater origin, whilst the southern ones are in part at least marine. The country has since been much dissected, especially in its northern parts, with the result that the sediments in places now form merely the caps of the hills.

The sediments of the Greensborough area are now disconnected by erosion, but are found high up the hills at apparently the same

1 Portion of this country has, I understand from Prof. Skeats, been independently mapped by Mr. Junner of the Melbourne University (he being unaware of my work amongst the basalts of the district), and a paper thereon has been read by him before this Society. At the time of writing (6th March, 1913) this paper has not been published, nor has it been seen by me, so that both Mr. Junner's and my own conclusions are each independent of the other's.

2 In places the basalt rests directly on the Silurian. The explanation is that either from the contour of the country, the gravels and grits never covered these particular places, or that they have been removed by denudation before the flow of the basalt.

3 For a definition of this peneplain, see the writer's paper on the Physiography of the Yarra previously cited, p. 477.

general level. The latter also appears to be continuous with that of similar deposits to the south referred to above In their lithological and general characters, the deposits are similar, except that in the Greensborough area they are much coarser-grained in places, consisting largely of very heavy gravels.[1] This, however, is what would be expected on approaching the hills (to the north), from which the rocks are derived. The most reasonable inference is that the Greensborough sediments belong to and are of the same age as those to the south. These, by the fossils obtained at Royal Park and Beaumaris, have been placed as Kalimnan, so that if the Greensborough gravels and sands belong to this period, the Older Basalt of the district may be considered as Kalimnan, or younger.

The Older Basalt at Royal Park and other localities farther west underlies the Barwonian, hence it must be of this or of an earlier age. There is therefore a very considerable time gap between the Older Basalt of Royal Park, Saltwater River, etc., and the Older Basalt of Greensborough.

The latter rock is much older than the Newer Basalt of the plains. The Greensborough area clearly shows (as pointed out by Mr. Hart) that before the eruption of the Newer Basalt, the Older Basalt had been much denuded and the country deeply dissected. A large time-gap also therefore exists between the Older Basalt and the Newer Basalt of the Greensborough district. There is thus evidence of three distinct basalt periods, separated by wide intervals of time, in the neighbourhood of Melbourne.

If the Older Basalt of Greensborough were of the same age as that of Royal Park, the underlying sediments would be much older than Kalimnan, and would probably be contemporaneous with the sedimentary beds below the Royal Park basalt, but the available evidence points in the writer's opinion rather to Kalimnan age than to a much older period.

In the Greensborough area, most of the Kainozoic sediments are closely associated with the basalts. The latter have apparently acted as protective caps, and when the basalt is removed the sediments soon follow. Farther south there are numerous outcrops of sediments uncapped by basalt. Greater thickness of sediments in this direction (towards the sea) would, however, be expected, and this thickness would temporarily save some rocks from removal by denudation. In view, moreover, of the evidence brought forward in this paper, it is impossible to say to what extent basalt may have overlain the sedimentary rocks.

1 Similar gravels are also found at Kangaroo Ground.

The Kangaroo Ground Older Basalt.

The main portion of this basalt occupies a fairly extensive belt of high country a few miles to the east of the Greensborough basalts. As seen in the road cuttings, it is very vesicular, and considerably decomposed in parts. In the former character it differs from the Greensborough Older Basalts, as the latter, so far as observed, are generally dense.

Beneath the basalt are some gravels, grits and sands, which have in places been worked for gold. These sediments, together with their silicified products, quartzites, can be noticed at the edges of the basalt on the northern and eastern sides of the main outcrop. Quartzite boulders are found in other parts, and in the township of Kangaroo Ground there is a rather extensive outcrop, which also apparently underlies the basalt.

An actual section of the basalt covering the sediments is seen to the east of the small quarry reserve in Allotment 16, Section III., Parish of Nillumbik. The basalt cap here is only a few yards in diameter, but it rests on grits and gravels of an exposed thickness of about 16 feet, so that any doubt as to the relations of the two rocks is set at rest.

The Geological Surey has marked on the parish map of Nillumbik the "probable course of lead" under the basalt, thus indicating a belief in the existence of an old buried river channel. The basalt at Kangaroo Ground certainly in parts lies on a very uneven surface, as may be seen on the main road running north to the township from Eltham. By Weller's Temperance Hotel, at the foot of a long hill, the basalt outcrops and overlies gravels, whilst towards the top of the same hill going north it rests on Silurian rocks. In this uneven surface, it appears to differ much from the Greensborough Older Basalts. Elsewhere, however, in the vicinity, the general surface on which both the basalt and gravels lie seems moderately level.

The question of the age of the Kangaroo Ground basalt is not easily answered. The writer, in his paper already referred to on the physiography of the Yarra Basin, regarded this rock (through adapting the current ideas of its age as that of the typical Older Basalt of Royal Park, etc.), as a monadnock on the Nillumbik Peneplain, and therefore older than the latter. The cap of Kainozoic sands and gravels around Melbourne rests on the peneplain, and is therefore younger or at least coincident with the final stage of formation of the peneplain. Considering the Greensborough gravels and sands as part of this cap, makes the Older Basalts of the same

district younger than the peneplain; whilst if the Kangaroo Ground basalt be a monadnock on the peneplain, there is a great gulf between the respective Older Basalts of the two places. If, on the other hand, it be not a monadnock, but part of a flow subsequent to the formation of the peneplain, both it and the Greensborough rocks would probably be of the same age, but separated from the Royal Park flow by a great interval of time.

The point might be satisfactorily settled if the age of the sediments below the respective basalts at Kangaroo Ground and Greensborough could be determined beyond doubt, but unfortunately no fossils have been discovered at either place, and thus the most reliable proof is absent.

The proximity of the two areas, the generally similar characters of the underlying sediments, and the roughly level, continuous surface over which the basalts have flowed suggest their identity in age. In favour of their difference is the uneven valley-like surface on which the Kangaroo Ground basalt in part rests, and the discrepancy in the character of the rocks (vesicular and dense) already noted, but these are of a somewhat frail nature on which to make a great time gap. Provisionally, therefore, these basalts may be held to be of the same age, and as the Greensborough Older Basalt belongs probably to the Kalimnan or later period, the Kangaroo Ground basalt must tentatively be placed there. If this be correct, the latter is not a monadnock on the Nillumbik Peneplain.

No distinct vents have been discovered in the basalts of Greensborough or Kangaroo Ground. Garden Hill, at the latter place, rises considerably above the general level of the surrounding basalt and it is just possible that this may represent the worn-down vent from which the lava was spread over the country.

Streams cut through the Older Basalt at Greensborough, but are deflected away from that at Kangaroo Ground. Either a monadnock on the old peneplain or a high mass (such as exists), due to being the remains of a vent, would cause this peculiarity.

The Mount Cooper Newer Basalt.

As previously indicated, the basalt forming the cap of Mt. Cooper, Bundoora, is shown on the Survey Quarter-Sheet as continuous with the Newer Basalt flows on the plain to the west. On a visit to the locality some years ago, the writer accepted this view, but in consequence of subsequent examination of the Greensborough basalts, and the high-level basalt at Ivanhoe, together with the distribution of the basalt around Mt. Cooper, as shown by the map,

some doubt has arisen as to its correctness. On a recent visit to Melbourne, the writer intended to visit the ground, but unfortunately time did not permit. The question is, however, now brought forward as a suggestion for further investigation.

Mt. Cooper is a rather prominent landmark, rising to a fair height above the Newer Basalt of the Darebin Creek valley, and having steep northern and western faces. There is a large patch of Kainozoic sediments (most of which have been converted into quartzite), which rest on the Silurian rocks of the district, and underlie the basalt. This quartzite outcrops freely on the northern, western and southern slopes of the hill, and is found right in the bed of the Darebin Creek to the west.[1] These silicified gravels and grits are no doubt part of, and originally continuous with, the Kainozoic sediments of Preston and Greensborough, to which reference has already been made.

The basalt cap is at the northern end of the hill, and is probably from 40 to 50 feet thick at the highest point. This basalt, when examinued *in situ*, is, so far as observed, dense and non-vesicular. Its boundaries are clearly shown on the northern, southern and western sides, where the quartzite already referred to crops out from beneath the basalt. To the west, in the valley of the Darebin Creek, is the low-lying lava flow, the typical Newer Basalt of the district, from which the high basaltic cap of Mt. Cooper is separated by the quartzite.

According to the Survey map, the basalt of the hill is continuous with the lower basalt at its north-eastern end, and on this ground no doubt, the higher basalt has been mapped as Newer Basalt, and the hill consequently regarded as a volcanic vent. An important question therefore is whether the two basalts are actually connected or not.

At first sight there appears to be no doubt that such a connection exists, as although an actual outcrop cannot be continuously traced, the heavy black soil resulting from the decomposition of basalt forms an unbroken line on the north-eastern face. In addition, near the top of the Mount, and on the same face, numerous pieces of very vesicular basalt of low specific gravity, which might for convenience be called basaltic pumice, occur. This is somewhat suggestive of a vent in the neighbourhood. There is also a low hill between Mt. Cooper and the main road to the east, rising above the level of the low-lying basalt. This hill has highly vesicular basalt, which is apparently connected with the lower flow.

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1 This shows that at this locality the Kainozoic sediments were deposited on an uneven surface, or that they have been let down by faulting.

On the other hand, the Mount has been well dissected on most sides, and the basalt appears to be lying on the quartzite. If a plug exist, it occurrence has not yet been actually demonstrated. Again the basalt on the top of the quartzite, when examined *in situ*, is dense and non-vesicular, in this respect in hand specimens, resembling more the Greensborough Older Basalt than the typical Newer Basalt. It also occurs at such a height that if erosion had proceeded so far as to remove all traces of basalt on the north-eastern slope, the high basalt would certainly have been regarded merely as another outlier of such Older Basalt of Greensborough. It is for these reasons that the writer ventures to doubt the correctness of the Survey interpretation.

In the absence of a sufficient examination of the area since this doubt arose, a definite opinion on the point cannot be offered, but as a hint to anyone taking up the investigation, attention should be paid to the low hill to the east, which may be the remains of an old vent of the Newer Basalt period. If so, the occurrence of such basalt above its general level might be explained, and at the same time make it possible for the basalt on the top of Mt. Cooper to be another outlier of the Older Basalt of Greensborough or perhaps the plug of an old vent of such Older Basalt, but there is little more (if any) ground for the latter alternative than for any of the basalt caps of the Greensborough area.

Microscopical examination might throw some light on the question, and the small patches of Newer Basalt on the eastern side of the main road at Bundoora (which the writer has not seen) should also be studied.

The Ivanhoe High-Level Basalt.

On several occasions some years ago, the writer endeavoured to locate the "basalt boulders" marked on the Quarter-Sheet. The "siliceous conglomerate" was easily fixed by an outcrop on the roadside, but no trace of the basalt could be found, and the matter was dismissed as a mistake of the field geologist or draftsman. Some time later, however, on happening to pass that way again, several holes up to about 4 ft. deep were being dug in connection with the formation of a nursery, and in these holes the "basalt boulders" revealed themselves, thus offering another testimony to the remarkable accuracy of the early Victorian Geological Survey. The basalt was close to the siliceous conglomerate, and apparently only a few yards in extent.

The "basalt boulders" consisted of rounded, semi-rounded and angular blocks, having on the average a diameter of about 10 inches

of hard, non-vesicular, dense basalt. Some blocks were polygonal in shape. The writer has no doubt that these boulders are not waterworn, but are the remains of basalt *in situ*, jointed into small vertical columns, and then weathering into the observed forms by exfoliation, i.e., spheroidal weathering.

The rocks were found near the crest of the ridge to the east of the Darebin Creek, and high above and disconnected from the Newer Basalt flow of that valley.

The actual relation to the silicified sediments could not be seen, but the latter may be taken to represent a small altered patch of the ordinary Kainozoic sediments of the district. The silicification is apparently connected with the basalt, and the latter would probably therefore be younger. It is evidently older than the Newer Basalt, and its most likely age is that of the Older Basalt of Greensborough, and of the cap of Mt. Cooper, if the latter ultimately turn out to be of the same age as the former, the likelihood of which is, in the writer's opinion, strengthened by the Ivanhoe example. The possibility of the basalt being a volcanic plug of the Greensborough Older Basalt period must also be borne in mind, although there is no direct evidence on the point.

It is interesting to observe that only at this locality (where basalt is associated with them) are the Kainozoic sediments of Ivanhoe and Heidelberg silicified to such an extent as to merit the term quartzite being applied to them. Yet at Greensborough basalt caps are numerous, and scarcely any silicification has taken place, but at Kangaroo Ground both silicified and unsilicified Kainozoic sediments underlie the basalt. At Mt. Cooper the underlying sedimentary rocks have been extensively silicified. Mr. Armitage[1] has suggested a cause for the silicification of similar rocks in the Essendon district, but the matter cannot here be discussed.

The Physiographic Relations.

As we have seen, the question of the age of the basalts and sediments is bound up with the physiography of the district.

The following points appears to be well established. To the north, east and south of Melbourne, the higher hills are capped by Kainozoic sands and gravels, which were originally continuous and rested upon a practically level surface of the older rocks, this surface representing an old base-level of erosion, which stretched far up the Yarra valley, and which for convenience has elsewhere been called the Nillumbik Peneplain. These gravels and grits around

1 Vic. Nat., vol. xxvii. (1910), p. 92.

Melbourne are in part marine and in part freshwater. They were laid down on the Nillumbik Peneplain at the base-level of the latter. Subsequently the country was elevated, and a fresh cycle of erosion commenced, with the result that the Kainozoic sediments have been partly broken up into the present disconnected caps on the hills, and in the resulting valleys the Newer Basalt has flowed. Judging by what are regarded as the marine representatives of these sedimentary beds at Royal Park and Beaumaris, their age is Kalimnan. The Older Basalt at Royal Park is clearly older than the Kalimnan beds there, as the latter overlie the Barwonian, and these in turn the basalt.[1]

Passing now from these fairly well established conclusions, reasons have already been given for believing the Kainozoic sediments of Greensborough, Ivanhoe and Mt. Cooper to be Kalimnan; for classifying the overlying basalts at Ivanhoe and Greensborough as Kalimnan or later; for considering the possibility of the Mt. Cooper basalt being of the same age; and for provisionally placing the Kangaroo Ground sediments and basalt with the similar rocks of Greensborough.

From physiographic considerations it would seem that the Older Basalts, the subject of this paper, must have been poured out before the underlying sediments were broken up by erosion, and consequently before or soon after their uplift from base-level; for if any great interval elapsed between the uplift and the basalt flows, denudation would have brought about such inequalities of the land that the basalt, instead of as a rule, now regularly capping the hills, would have been found also in the valleys, but of this there is no evidence, except in part at Kangaroo Ground, as already recorded, which, however, may be due to some local cause.

Summary.

Gravel, grits, sands and their alteration product, quartzite, are found at Ivanhoe. Mt Cooper, Greensborough and Kangaroo Ground at high levels, associated with the basalts. The latter overlie the sediments at three of the localities, and at the fourth (Ivanhoe), the same relation probably holds good.

No fossils have yet been discovered in these sedimentary rocks. In their absence, the evidence points to those at Greensborough and Mt. Cooper being continuous with and of the same age as those farther south (which include the Ivanhoe area), and which are re-

1 As to the general Kainozoic history of the country around Melbourne, see "Victorian Hill nd Dale" and other writings by Dr. T. S. Hall.

garded as Kalimnan. The overlying basalt at Greensborough and that at Ivanhoe must therefore be Kalimnan or younger, but it is uncertain whether the Mt. Cooper basalt belongs to the same series or to the Newer Basalt period.

The Kangaroo Ground sediments and covering basalt are on a balance of probabilities provisionally placed with the similar rocks of Greensborough.

The evidence therefore shows a series of basaltic outliers, which point to a distinct period of vulcanicity between the typical Older Basalt of Royal Park and the Saltwater River, and the Newer Basalt of the plains, the intermediate period being separated from each of the others by a great time gap. It is suggested that the terms Older Basalt and Newer Basalt be retained for the rocks above indicated by those names, as they are now well established and understood, whilst the term Intermediate Basalt be used for the basalts of the intermediate period.

On the above reading, the Kangaroo Ground and other basalts cannot be considered as monadnocks on the Nillumbik Peneplain, as they are younger than such peneplain.

Garden Hill at Kangaroo Ground may be a worn-down vent of the Intermediate Basalt.

From the physiography of the district it is inferred that the Intermediate Basalt was poured out before or shortly after the uplift of the Nillumbik Peneplain.

In conclusion, it is well to state that the want of definite conclusions on the various points raised in this paper is chiefly due to two reasons—first, the unsatisfactory character of the evidence itself, and second, the incomplete examination of the ground by the writer on account of his removal from Victoria to Western Australia.

Sufficient data have, however, been brought forward to show that not only a thorough investigation from all points of view of the basalts and associated sediments of the area dealt with in this paper and of adjacent districts is required, but also that the Older Basalts of the State as a whole should be subjected to a close re-examination as opportunity offers.

The difficulties attending attempts to fix the age and stratigraphical relations of the Victorian basalts have been pointed out by Prof. Skeats.[1]

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1 Pres. Add. (Sec. C), A.A.A.S., Brisbane. 1909, p. 199 et seq.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913].

Art. IV.—*On the Occurrence of a Felsitic Dyke and Associated Breccias at Sugar Loaf Hill (Mont Park), near Heidelberg.*

BY

J. T. JUTSON

(Geological Survey of Western Australia).

AND

FREDERICK CHAPMAN, A.L.S., &c.

(National Museum, Melbourne),

(With Plate VI., and one Text Figure).

[Read 10th April, 1913].

Introduction.

Sugar Loaf Hill is an elongated hill running about north-north-west, and is 440 feet above sea level. It lies a little to the north of Heidelberg, and constitutes a prominent landmark, from which a fine panoramic view can be obtained.

As already pointed out by one of us (J.T.J.[1]) the hill is a monadnock on the Nillumbik Peneplain.

Previous literature.

References to this hill are few. Selwyn, in the map accompanying his report on the geological survey of the Yarra basin and Western Port,[2] has mapped it as a "siliceous dyke of red jasper and white quartz rock." On Quarter-Sheet 2 S.E. (Aplin, 1868), it is noted that on the hill there are outcrops of a "hard and flinty 'breccia,' composed of angular and here and there a few semi-rounded pieces of sandstone and altered shale," and the suggestion is made that this breccia has, in all probability, filled a pre-existing fissure in the bed rock.

Mr. T. S. Hart, M.A., in his "Volcanic Rocks of the Melbourne District,"[3] inclines to the opinion that Sugar Loaf Hill was once the bottom of a lava-filled valley, that the lava has been removed,

1 Proc. Roy. Soc Victoria, vol. xxiii. (N.S.), pt. ii., 1911, p. 502.

2 "The Basin of the River Yarra and part of the Northern, North Eastern and Eastern Drainage of Western Port Bay." Votes and Proceedings, Leg. Council, Victoria, 1855-6, vol. ii., pt. i.

3 Vict. Nat., vol. xi., 1894, pp. 74-78.

but that the hardened drift of the stream bed remains, capping the hill.

Since Mr. Hart wrote, some very small excavations on the top of the hill have been made.

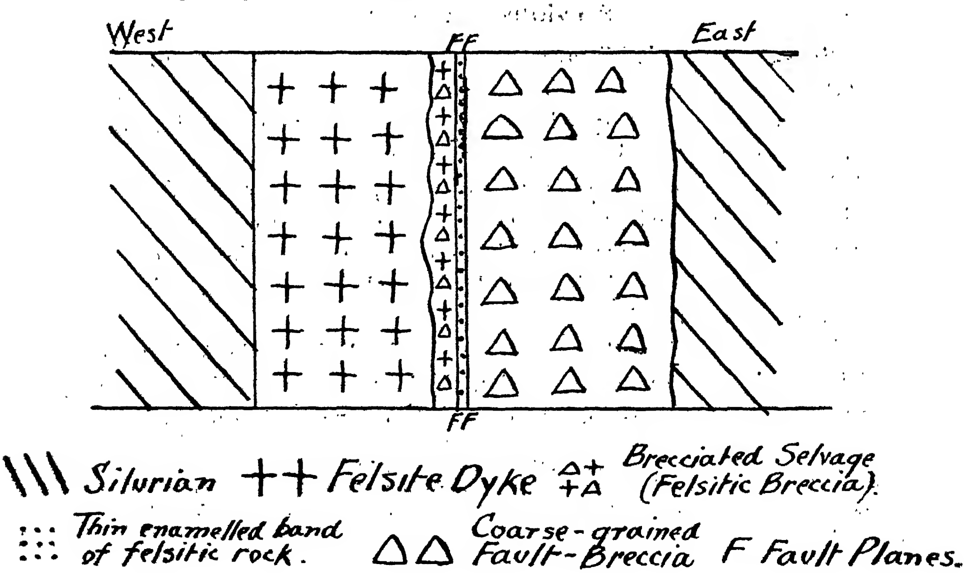
General Description of the Outcrops and Sections.

The country surrounding Sugar Loaf Hill consists of Silurian sediments (mainly shales with thin bands of sandstone), with a strike some degrees to the east of north. We believe the main part of the hill to be of similar lithological character, and the rocks to possess a similar strike, although the latter point is not directly ascertainable.

On the top of the hill a band of rock (which we regard as a felsitic dyke intrusive into the Silurian) runs approximately north-north-west for about 300 yards. A branch is thrown off from about the centre, and runs northerly for about 100 yards on the east of the main portion of the dyke. The outcrops are faint for about 50 yards north of the bifurcation. Between the two branches of the dyke there is exposed a moderately coarse-grained sandstone, with thin quartz veins. The width of the dyke varies from about 6 to 30 feet.

Associated with the dyke is a very coarse-grained breccia, which we consider to be a fault—or friction-breccia formed subsequently to the dyke.

At a shallow excavation about 18 inches deep, and about 3 feet long, towards the southern end of the main outcrop of the dyke, a small but interesting section is disclosed, which is shown by the following diagrammatic figure:—



The Silurian rocks are not seen in the actual section, but are inserted to show the relations.

The dyke at this section is about 12 feet wide; the brecciated selvage would average about 2½ inches, but reaches 5 inches; and the enamelled rock is about ¾ inch in width. The width of the fault-breccia has not been defined, but about 4 feet of it can be seen. The eastern face of the enamelled rock is smoothed, polished and marked by faint, approximately horizontal striations, evidently indicating considerable rock movement. The petrology of this rock and of the dyke and selvage are described later.

The fault-breccia is composed of angular fragments of apparently fine-grained sedimentary rocks (no doubt of Silurian age), of the dyke rock and of the selvage, the size of the fragments varying from about 10 inches to ¼ inch.

The selvage, on its western side, passes into the dyke by an irregular, indistinct line, the rocks having the appearance of being fused together. The junctions of the enamelled rock with the selvage and the fault-breccia respectively are sharp, practically vertical, and run approximately parallel to the course of the dyke; they are regarded by us as fault planes. The actual junctions of the dyke and the fault-breccia respectively with the Silurian cannot be seen.

At another small excavation (now filled in), and elsewhere on the hill, generally similar relations between the main rocks occur. Points of difference are that the selvage is nearly three feet wide in places, and is sometimes cavernous, and that well down on the south-eastern slope of the hill, a coarse-grained breccia occurs, but the dyke appears to be absent.

On the northern slope of the hill, and a few feet below its summit, there is a small outcrop of hard silicified coarse grits. These rocks evidently belong to the series of Kainozoic gravels and grits capping the hills at Preston, Northcote, Heidelberg, Studley Park, and other places. They do not appear to have been disturbed by any earth movement.

Petrology.

The following is a description of the three principal types of rock.

The dyke rock is compact, of a chalky-white appearance, obscurely laminated near its edge, and in places stained with iron. Traversing the rock are numerous small, irregular planes, which may be due partly to shrinkage on cooling, and partly to the severe pressure the rock has sustained during the various earth movements, which have occurred subsequent to its intrusion. Along certain planes, bands of the brecciated selvage occur, showing clearly that the brecciation of the dyke was not confined to its eastern edge.

Under a high power of the microscope, thin sections (Plate VI., fig. 4) are seen to consist of a felsitic ground mass with altered felspars giving a shadowy extinction, small blebs of quartz, numerous tufts of sericitic mica, and occasional pale green tourmalines. On the field evidence the rock would be classified as an acid dyke. Under the microscope, however, on account of the decomposition that has taken place, it might possibly be regarded either as a fine-grained dyke-stone or as a volcanic ash; but from a consideration of both the field and microscopic evidence, we are of opinion that it is a fine-grained decomposed felsite.

The selvage rock from which the slide (Plate VI., fig. 3) has been taken is a brick-red jaspery breccia. Some of the included fragments measure as much as ·11 mm. in diameter. These seem to have been originally sandstones and secondary quartz vein-stone. Certain of the quartz fragments are distinctly rounded (due probably to crushing), and some show characteristic polysynthetic structure under crossed nicols. The brecciated rock-fragments are cemented by a ground mass of fine felsitic material, which has a purplish or reddish tint owing to the quantity of haematite included in it in segregation patches, and bordering the larger fragments of polysynthetic quartz. Sericite is abundant in minute flakes in the matrix of the rock, and traces of a large simply twinned orthoclase on the (?) Baveno type also occur. Many of the secondary quartz fragments show interesting stress shadows as well as micro-gneissic structure. Macroscopically this rock resembles a volcanic breccia, with included fragments of sedimentary Silurian torn from the rocks adjacent to the fissure. This term, however, generally implies a pyro-clastic rock formed by an explosion from a volcanic vent, which does not appear to be the case with the rock in question. It is better described simply as a felsitic breccia. It may have been formed either by the dyke on its intrusion tearing off fragments of the adjacent rocks, which became mixed with the dyke-stone at or near the margin of the dyke, or by earth movements causing the dyke to be brecciated subsequent to its consolidation. As the dyke-stone appears to form the matrix of the brecciated selvage, and the rocks have no distinct boundary line, but are irregularly fused together, we incline to the former explanation.

A certain amount of mineralisation of the rocks, particularly this selvage rock, has taken place, as shown by the thin veins and patches of pyrites and other minerals in hand specimens.

The enamelled rock is of an ochreous yellow to a brown colour. It resembles a fine-grained laminated ash breaking up into several

distinct platy layers, disposed parallel to the wall of the fissure. Its eastern face is, as already noticed, polished, and faintly striated. The dynamical movement to which the rock has been subjected probably accounts for the laminated appearance.

This rock in thin sections (Plate VI., figs. 1 and 2) under a moderately high power, is seen to consist of fine felspathic material closely felted, with larger fragments of altered felspars and extremely angular fragments of quartz. These larger fragments are arranged rudely parallel to the walls of the fissure. The very fine felsitic constituents, by being impregnated with limonite, are not conspicuously anisotropic under crossed nicols, but the edge of this thin band of rock has lost its iron, being very clear in excessively thin sections, and giving striking polarisation effects. A still higher magnification reveals the presence of minute fragments of pale green augite, occasional red-brown rutiles, and numerous rounded crystals of zircon. Throughout the rock there are ragged fragmentary folia of biotite, whilst disseminated here and there may be seen limonitic granules, probably decomposition products resulting from the alteration of biotite, and other ferro-magnesian minerals.

The rock may be described as a fragmental felsitic rock resembling an ash, but its origin is a difficult problem. There are three posible solutions :--(1) A thin intrusion of a felsitic character much later than the main dyke itself; (2) a true acid volcanic ash; and (3) a fragmental rock due to the grinding of the walls of the fault fissure, the constituents of the rock consequently being derived largely from igneous rocks.

Concerning (1), it is difficult to understand the completely crushed quartz, and the entirely fragmental character of the matrix, for so much dynamical stress would surely result in chemical changes within the rock itself. With regard to (2) the microscope rather favours this suggestion, but it is difficult to account for such a thin band of volcanic ash in such a position, considering that it is clearly not interbedded with the Silurian sediments of the area, and that it is extremely unlikely that a narrow fissure would remain open, and become filled with pyroclastic material to such a depth as this fissure must have possessed, in view of the very considerable denudation to which the rocks must have since been subjected. The most favourable solution appears to be (3), but whilst we incline towards this idea, we think the origin of the rock must be left an open question for the present.

We are indebted to Mr. D. J. Mahony, M.Sc., for assistance in elucidating the petrology of the rocks examined.

Conclusions.

A dyke of felsite is considered to have intruded the Silurian sediments by a forked fissure across the line of their strike.

Associated with the dyke is a brecciated selvage, which we have termed a felsitic breccia. We consider it probable that this rock originated by the dyke on intrusion, tearing off and enclosing fragments of the adjoining rocks Another aspect has been mentioned above.

After the formation of the brecciated selvage, a strong earth movement took place, by which the present coarse-grained fault or friction breccia was formed.

Later, further dynamic changes occurred along the same line of fracture, as indicated by the features of the thin enamelled band of rock, but as the origin of the latter is not clearly determined. nothing very definite as to the displacement can be stated, except that it was, in part at least, almost horizontal.

Thus, including the original fissure, we have evidence of several distinct earth movements along the same line of fracture, and so strikingly confirming the general statement that lines of weakness often suffer from repeated displacements. The rocks have probably been altered by thermal waters as well as by dynamic agencies.

Rgarding the age of the dyke and breccias, if our reading of the phenomena be correct, they are clearly post-Silurian. The Kainozoic grits at the northern end appear to belong to the series of gravels and grits that cap the higher hills to the north-east of Melbourne, such as Northcote, Studley Park and Preston, which are regarded as Kalimnan. As these grits do not appear to have been affected by the earth movements, all such movements, together with the date of the intrusion of the dyke, must be regarded as pre-Kalimnan.

It is possible that the dyke is contemporaneous with the felsitic dykes, which can be seen intruding the Silurian along the Alexandra Avenue, Melbourne.

EXPLANATION OF PLATE

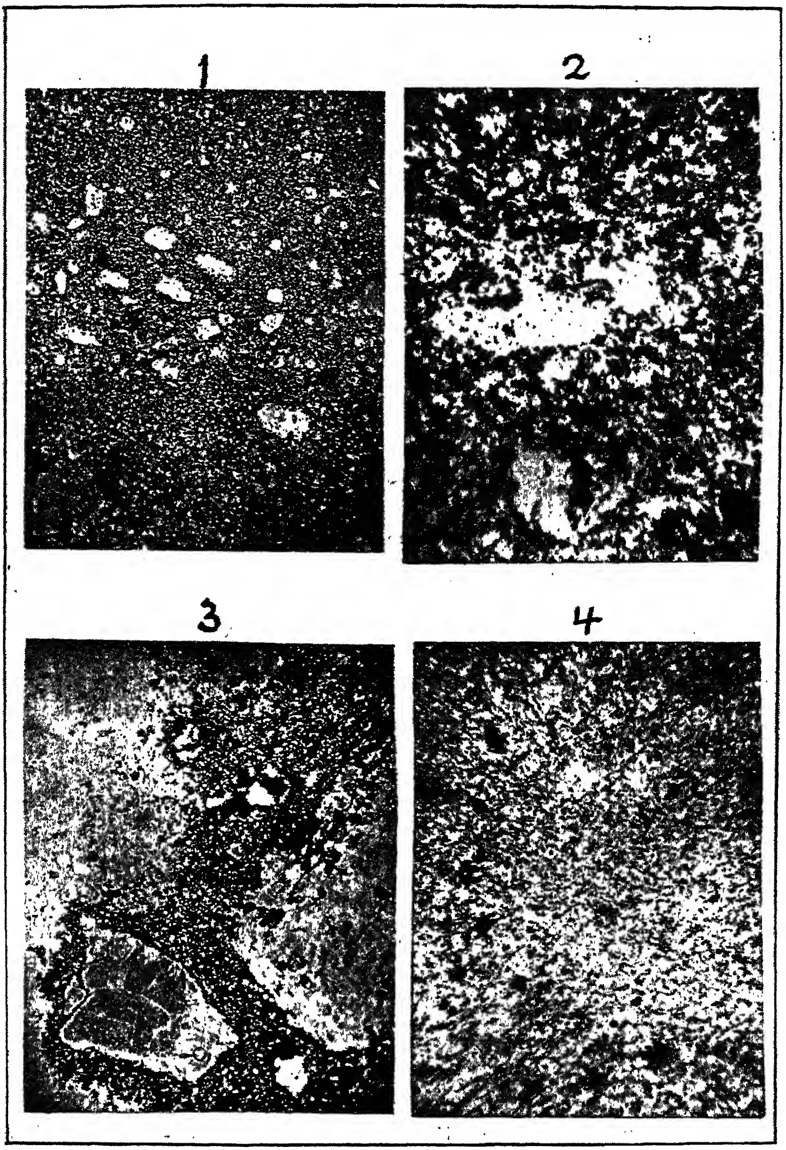
Plate VI.

Fig. 1.—Fragmental felsitic rock from the enamelled band in section near southern end of outcrop, Sugarloaf Hill. Slide No. 1. × 28.

Fig. 2.—The same, more highly magnified. Slide No. 1. × 184.

Fig. 3.—Felsitic-breccia, with quartz-vein fragments and altered sandstone, southern outcrops. Slide No. 2. × 28.

Fig. 4.—Felsite. From the dyke, southern outcrop. Slide No. 3. × 28.



F. C. Photo.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913.]

Art. V.—*On Natica tasmanica, Tenison-Woods, and description of a New Species of Natica.*

BY

G. B. PRITCHARD, D.Sc., F.G.S.,

AND

J. H. GATLIFF.

(With Plate VII.).

[Read 8th May, 1913.]

When making out the Catalogue of the Marine Shells of Victoria we included *Natica tasmanica*, T. Woods,[1] in the synonymy of *Natica didyma* (Bolton m.s.); Chemnitz, and also cited as synonyms *N. ampla*, Philippi, *N. bicolor*, Philippi, and *N. chemnitzii*, Recluz (non Pfeiffer), and *N. lamarckiana*, Recluz, and gave other references.

We had previously obtained specimens of *N. tasmanica*, T. Woods, from Dr. J. C. Cox, and Miss Lodder, named *N. didyma*, Bolten, obtained in New South Wales and North-West Tasmania.

The original description of *N. tasmanica* by T. Woods[2] is as follows :—"*N.* shell, with a somewhat covered umbilicus, depressedly orbicular, thick, with a short but slightly exsert spire; whorls convex, rounded, smooth, or obliquely thickly and most minutely striate, aperture semilunar, horizontal, columella somewhat thin, with a prominent callosity, which is spirally sulcate, umbilicus angularly excavate; with a kind of callosity within the suture at the mouth; pale fulvous or whitish, banded with brownish or orange lines; base white, chestnut or fulvous within."

In the National Museum, Melbourne, three specimens were set out on a card as *N. tasmanica*, T. Woods, dated January, 1877, and numbered 35315-7 locality, Hobson's Bay, and are duly entered under that name in the museum register. They answer to the above description. The Curator, Mr. Kershaw, informs us that at about that time the Rev. J. E. T. Woods examined their Australian shells and assisted in their identification, and probably the name was furnished by him.

1 Proc. Roy. Soc. Victoria, 1900, vol. xii. (n.s.), pp. 191, 192.
2 Proc. Roy. Soc. Tas. for 1875, pp. 148, 149.

Mr. Whitelegge, in his "List of the Marine and Freshwater invertebrate fauna of Port Jackson and the neighbourhood,"[1] lists the species as *N. didyma*, Bolton, m.s., Philippi.

Messrs. Tate and May, in their "Revised Census of the Marine Mollusca of Tasmania,"[2] quote the same shell as *Polinices ampla*, Philippi, and give *Natica lamarckiana*, Recluz, as a synonym, and subsequently at page 448 state that *Natica ampla*=*N. didyma*, Bolten. They also[3] list as a separate species, *Polinices tasmanica*, T. Woods, and give a figure[4] of a shell that is not his species; it does not answer to the description, being of a different form, with the umbilical callosity entire, and not spirally sulcate.

Messrs. Pilsbry and Vanatta, in a paper entitled "Notes on *Polinices didyma*, with description of a new Australian species,"[5] describe and figure *N. tasmanica*, T. Woods, as a new species, under the name of *Polinices aulacoglossa*,[6] type locality Altona Bay, Williamstown, near Melbourne, Victoria, and remark, "Some specimens received from Dr. J. C. Cox are larger, alt., 41½ diam., 42 mm., otherwise similar. This is apparently the form listed by Messrs. Pritchard and Gatliff as *Natica didyma*, Chemn., It is certainly distinct specifically from *P. didyma*, or any of its subspecies.

Natica chemnitzii, Recluz (not *N. chemnitzii* Pfr., 1840) seems to be identical with this species, though if so it attains a larger size than any examples we have seen. In any case the name is a homonym, and cannot stand.

Natica tasmanica, Tenison-Woods, has been placed in the synonymy of *P. didyma*, by Messrs. Pritchard and Gatliff, but Tate and May, in their Census of Marine Mollusca of Tasmania (1901), have retained it distinct, a decision supported by the figure published by them, it is a far smaller species than *P. aulacoglossa*, alt. 13, diam. 16 mm.

It is unfortunate that Messrs. Tate and May figured the wrong shell. Mr. May's attention was personally drawn by one of us to the matter on 11th May, 1901. On 10th March, 1913, we wrote asking him where the type was. He replied, "There is in this instance unfortunately no type known to refer to, or authentic co-types," and admits that the wrong shell was figured by Prof. Tate and himself.

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1 Proc. Roy. Soc. N.S.W., 1889, p. 96, No. 406.
2 Proc. Lin. Soc. N.S.W., 1901, vol. xxvi., 375.
3 Loc. cit.
4 Loc. cit., pl. xxv., fig. 49.
5 Proc. Acad. Nat. Sci. Philadelphia, 1908, vol. lx., pp. 555-559, pl. 29.
6 Loc. cit., pl. 29, figs. 1-3.

We are surprised that Messrs. Pilsbry and Vanatta did not discover this fact, as Tenison-Woods states, amongst other clearly expressed items, "Columella somewhat thin, with a prominent callosity spirally sulcate." In Messrs. Tate and May's figure the callosity is not sulcate.

We adhere to our opinion that the slight differences existing between *N. didyma*[1] and *N. tasmanica* do not warrant the latter being considered a distinct species, and are of opinion that there is a closer resemblance between the two than we can discern between *N. didyma* and *N. bicolor*. The last-named is classed by Messrs. Pilsbry and Vanatta as a variety of *N. didyma*.

Whether the shell be considered to be a distinct species, a variety, or a synonym, the name given to it by Tenison-Woods has precedence, and *P. aulacoglossa*, Pilsbry and Vanatta, becomes a synonym.

Natica controversa, sp. nov. (Pl. VII., *Figs.* 1–3).

1901. *Natica tasmanica*, Tate and May, (non T. Woods), Proc. Lin. Soc. N.S.W., vol. xxvi., p. 375, pl. 25, f. 49.

Shell rather small, solid, globose, whorls about five, smooth, but for the slightly irregular lines of growth, spire short and slightly exsert, aperture ovate, outer lip rather strong, suture well defined with a strong enamel thickening internally; at the anterior end of the columella there is a narrow but defined tooth-like ridge, umbilicus angled, deep, about one-third of it covered by a semilunate callosity, which is convexly rounded on its surface, and does not bear any trace of a transverse sulcation. Colour light yellowish-white; on the body whorl there are two indistinct, darker encircling bands, the upper one being the broader, and extending from a little below the suture to the periphery; the other is narrow and near the base; there is also a light-coloured band below and adjoining the suture, due to the internal thickening.

Dimensions of Type.—Height, 15; breadth, 17 mm.

Locality.—South Coast, Tasmania.

Observations.—This is the species which was figured in error by Messrs. Tate and May (cited above), as representing *N. tasmanica*, Tenison-Woods, and referred to by us in the foregoing remarks upon that species.

Type in the National Museum, Melbourne; hitherto unnamed specimens No. 36265-6, have been on view since October, 1876. We have chosen No. 36265 as type. We have recently received two

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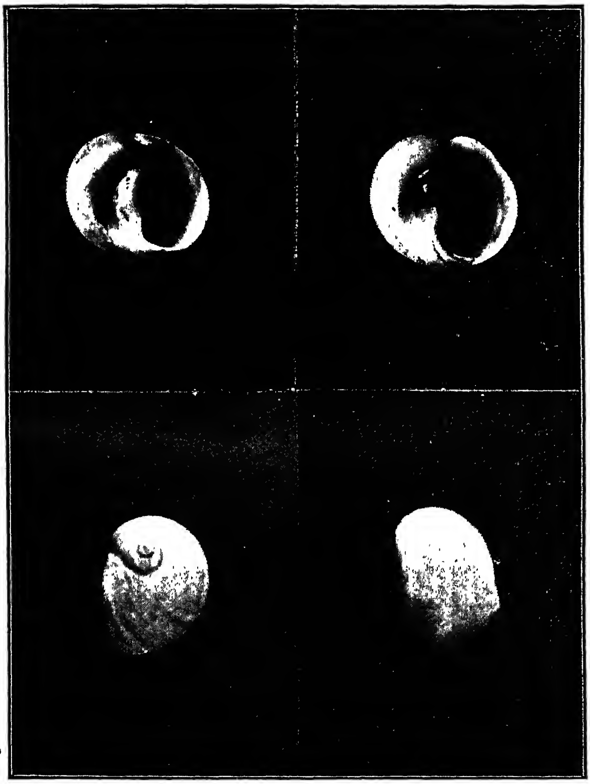
1 Of this species we have before us an example from Japan, verified by comparison with the shell under that name in the British Museum by Mr. C. J. Gabriel in 1907.

smaller specimens from Mr. May as being the species he figured, and these agree with our present species. Mr. May also states that the operculum is unknown.

EXPLANATION OF PLATE.

Figs 1-3.—Natica controversa, sp. nov.
Fig. 4.—Natica tasmanica, T. Woods.
All figures are natural size.



[PROC. ROY. SOC. VICTORIA, 26 (N.S.), PT. I., 1913].

ART. VI.—*On Some New Species and Varieties of Victorian Marine Mollusca.*

BY

J. H. GATLIFF

AND

C. J. GABRIEL.

(With Plate VIII.).

[Read 12th June, 1913].

This paper contains descriptions of three new species of *Rissoa*, one variety, and a new variety of *Bullinella pygmaea*, A. Adams; also remarks on and figures of *Rissoa bicolor*, Petterd.

Rissoa iravadioides, sp. nov. (Plate VIII., Fig. 1).

Shell minute, cylindrical, of four and a-half slightly convex lirate whorls, exclusive of the embryonic whorl, which is smooth; the following whorls are each encircled by about six flatly-rounded spiral lirae, equally spaced, the intervening grooves are concavely rounded, and of the same width as the lirae, the upper portion of the whorl is slightly tabulate below the suture, which is incised. The obliquely pyriform aperture is in the plane of the axis, and is laterally extended to the right, beyond the body of the shell, periphery rounded. Colour, cream-white.

Dimensions.—Length, 1.55; breadth, .55 mm.

Locality.—Dredged off Wilson's Promontory (type), also in 8 to 10 fathoms, Western Port.

Obs.—In general appearance somewhat resembling shells of the genus *Iravadia*.

Type in Mr. J. H. Gatliff's collection.

Rissoa janjucensis, sp. nov. (Plate VIII., Fig. 2).

Shell minute, sub-cylindrical, smooth, of five and a-half whorls, including the embryonic whorl, which is small; sutures linear, well defined; whorls flatly convex. Aperture in the plane of the axis, roundly pyriform, laterally extended to the right, peristome complete. Colour, pale yellow.

Dimensions.—Length, 1.5; breadth, .5 mm.

Locality.—Jan Juc, Puebla coast (type), in shell sand; also dredged in 8 to 10 fathoms Western Port.

Obs.—Another specimen is of reddish-brown colour, with the exception of the base and peristome, which gradually become pale yellow.

Type in Mr. J. H. Gatliff's collection.

Rissoa verconis, Tate; var. apicilata, var. nov. (Plate VIII., Fig. 3).

The species was originally named by Petterd *Rissoa badia*,[1] and the following is his description:—"Shell small, narrowly oblong, smooth; whorls 6, aperture small, labrum thick; apical whorls inflated. Long., 1.75; lat., .50 mm."

The name being pre-occupied by A. Adams in 1861, was changed by Tate to *R. verconis*,[2] and the shell was figured by Tate and May.[3] It has a rounded dome-shaped apex.

In the variety the apical whorl is oblique, and of a somewhat peculiar formation, the nucleus is not situated at the highest point, but drops down to the left. Colour, brown.

Dimensions.—Length, 2; breadth, .53mm.

Locality.—Type of variety, dredged in 6 to 8 fathoms Western Port; Port Albert (T. Worcester).

Rissoa wilsonensis, sp. nov. (Plate VIII., Fig. 4).

Shell minute, turreted, white, shining, semi-transparent. Whorls four, including a prominent dome-shaped protoconch. Whorls furnished with four elevated, rounded, spiral keels, the interstices being about twice the width. The body-whorl, with its eight carinae occupying slightly more than half the length of shell. Sutures deeply impressed. A microscopic examination of the interstices discloses a minute sculpture of numerous, slightly undulating spiral threads, crossed by threads of feebler strength. The protoconch is well defined, and ornamented with spiral lirae. Aperture, through which the spiral sculpture may be seen, ovate; labrum thin; inner lip slightly patulous.

Dimensions of Type.—Length, 1.5; breadth, .75 mm.

Locality.—Dredged off Wilson's Promontory.

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1 Jour. of Conch., 1884, vol. iv., p. 138.

2 Trans. Roy. Soc. S. Aust., 1899, vol. xxiii., p. 233.

3 Proc. Linn. Soc. N.S.W., 1901, vol. xxvi., p. 392, pl. 27, fig. 86.

Obs.—At present three specimens represent the species, one, possessing an extra whorl, attaining the dimensions of 2 mm. It has an ally in *R. layardi*, Petterd, which species possesses closer spirals and is more acuminate in form.

Type in Mr. C. J. Gabriel's collection.

Rissoa bicolor, Petterd. (Plate VIII., Figs. 5 and 6).

This species was described as being "without sculpture."[1] This is correct as far as concerns the body whorls, but a microscopic examination shows that the two-whorled protoconch is minutely granulated, these granules being symmetrically arranged in about twelve spiral rows, which are more clearly defined on the second whorl. The species also varies in size and outline, some being elongately pyramidal, as figured by Tate and May,[2] and others are smaller and more tumid in the whorls, we therefore give a figure of one of these, and a magnification of the embryo showing the feature above described.

Bullinella pygmaea, A. Adams; var. sculpta, var. nov. (Plate VIII., Fig. 7).

Shell thin, small, white, semi-translucent, sub-cylindrical, truncated at the top. Sculpture—the whole surface is scored with numerous, irregular, somewhat remote spiral furrows, and with longitudinals of a similar character, but more frequent. The top is narrower and margined with a slightly thickened radiatingly-marked rim, within which is an infundibuliform perforation. Aperture the full length of the shell, narrower above, and almost half the width of the shell at the anterior end. Outer lip, thin, sharp, nearly straight. A narrow, elongated, oblique pillar-lip appears, behind which is an umbilical chink, into which the sculpture is clearly traced.

Dimensions of Type.—Length, 1.25; breadth, .75 mm.

Locality.—Dredged off Wilson's Promontory.

Obs.—In the series of the variety studied variation existed. A general consistency in contour prevailed which warranted a variety being made, but with not sufficient distinction to rank it as more than a variety of the variable *B. pygmaea*, A. Ad.

Type in Mr. C. J. Gabriel's collection.

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1 Jour. of Conch., 1884, vol. iv., page 137.
2 Proc. Linn. Soc. N.S.W., 1901, vol. xxvi., page 391, pl. 26, fig. 63.

EXPLANATION OF PLATE VIII.

Fig. 1.—Rissoa iravadioides, sp. nov.
Fig. 2.—Rissoa janjucensis, sp. nov.
Fig. 3.— Rissoa verconis, Tate var. apicilata, var, nov.
Fig. 4.—Rissoa wilsonensis, sp. nov.
Fig. 5.—Rissoa bicolor, Petterd.
Fig. 6.—Rissoa bicolor, protoconch enlarged.
Fig. 7.—Bullinella pygmaea, A. Adams, var. sculpta, var. nov.
All the figures are variously magnified.

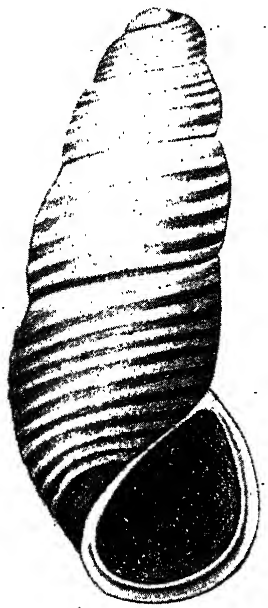

Fig 1.

Fig 2.

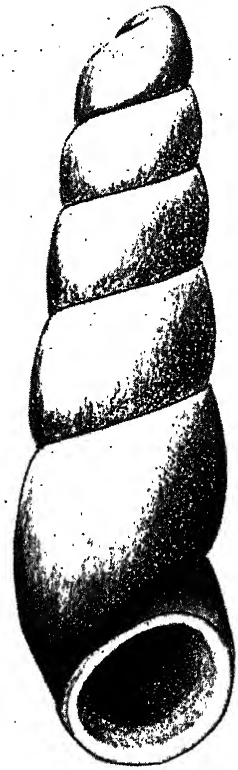

Fig. 3.

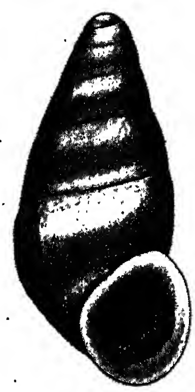

Fig. 5.

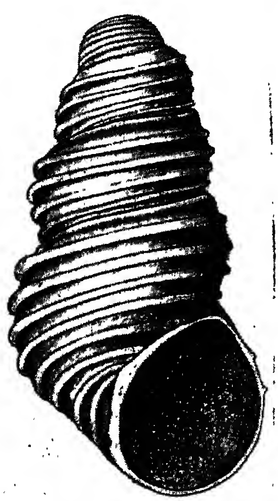

Fig 4.

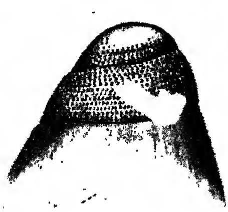

Fig. 6.

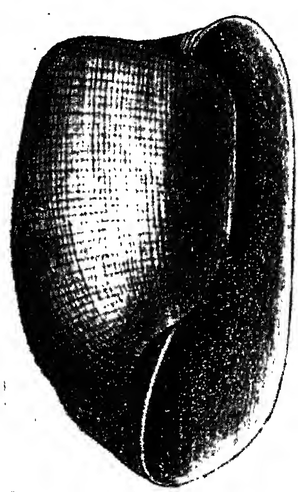

Fig. 7.

[PROC. ROY. SOC. VICTORIA, 26 (N.S.), PT. I., 1913].

ART. VII.—*Additions to the Catalogue of the Marine Shells of Victoria.*

BY

J. H. GATLIFF

AND

C. J. GABRIEL.

[Read 12th June, 1913].

In this paper we have made 69 additions to the catalogue, including 8 new genera, namely, *Euthria, Leucosyrinx, Eglisia, Phenacolepas, Cuspidaria, Ectorisma, Thyasira,* and *Cyrilla;* 3 new species and 2 new varieties described in the preceding paper, and the total number of mollusks catalogued is 1031.

In our generic nomenclature we have used the names adopted in the earlier portions of the catalogue. There have been changes made since, and some of the alterations have not been generally adopted, we purpose dealing with this matter in a future paper.

It will interest palaeontologists to note the inclusion of *Eglisia triplicata,* hitherto only recorded as a Tertiary fossil.

TROPHON RECURVATUS, Verco.

1909. Trophon recurvatus, Verco. T.R.S., S.A., vol. xxxiii. p. 336, pl. 24, f. 7, 8.

1911. Trophon recurvatus, Verco. May, P.R.S., Tas., for 1910, p. 307.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 6.7; breadth, 3 mm.

TROPHON SIMPLEX, Hedley.

1903. Trophon simplex, Hedley. Mem. Aust. Mus., vol. iv., p. 380, f. 93.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 8; breadth, 3.8 mm.

CYMATIUM KAMPYLUM, Watson.

1883. Nassaria kampyla, Watson. J.L.S., Lond., vol. xvi., p. 594.

1886. Nassaria campyla, Watson. Chall. Zool., vol. xv., p. 405, pl. 14, f. 12.

1900. Lampusia nodocostata, Tate and May. T.R.S., S.A., vol. xxiv., p. 90.

1901. Lampusia nodocostata, Tate and May. P.L.S., N.S.W., vol. xxvi., p. 355, pl. 23, f. 2.

1902. Lotorium nodocostatum, Tate and May. Kesteven, Id., vol. xxvii., pp. 463, 479; f. 1 and 4.

1906. Cymatium kampyla, Watson. Hedley Rec. Aust. Mus., vol., vi., p. 219.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 1.67; breadth, 0.8 inches.

CYMATIUM COLUMNARIUM, Hedley and May.

1908. Cymatium columnarium, Hedley and May. Rec. Aust. Mus., vol vii., p. 119, pl. 23, f. 15.

1908. Cymatium columnarium, Hedley and May, Verco, T.R.S., S.A., vol. xxxii., p. 343.

Hab.—Bass's Strait, Commonwealth trawler "Endeavour."

Obs.—Size of type: Length, 21; breadth, 8.5 mm. The identification has been confirmed by Mr. W. L. May, and we have since compared the shell with the type.

FASCIOLARIA AUSTRALASIA, Perry; var. BAKERI, Gatliff and Gabriel.

1912. Fasciolaria australasia, Perry. Var. bakeri, Gatliff and Gabriel. V.N., pp. 46-48, pl. 3 and 4, f. 1-7.

Hab.—Of type, Anderson's Inlet (Baker). Cape Howe, Commonwealth trawler "Endeavour"; Lakes Entrance; Port Albert (T. Worcester).

Obs.—Size of type of variety: Length, 93; breadth, 41 mm.

Genus Euthria, Gray, 1850.

EUTHRIA TABIDA, Hedley.

1904. Phos tabidus, Hedley. P.L.S., N.S.W., vol. xxix., p. 191, pl. 8, f. 18.

1907. Euthria tabida, Hedley. Rec. Aust. Mus., vol. vi., p. 286.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 12; breadth, 5 mm.

VOLUTA PAPILLOSA, Swainson; var. KENYONIANA, Brazier.

1897. Voluta kenyoniana, Brazier. P.L.S., N.S.W., vol. xxii., p. 779.

1906. Voluta papillosa, Swainson. Var. kenyoniana, Brazier. E. A. Smith, P. Mal. Soc. Lond., vol. vii., p. 6.

1912. Voluta papillosa Swainson. Var. kenyoniana, Brazier. Verco, T.R.S., S.A., vol. xxxvi., p. 228, pl. 14, f. 2, 3.

Hab.—Cape Everard; Lakes Entrance.

Obs.—The variety is longitudinally irregularly costate, and the costae vary in number and development on different specimens. The size of the type of the variety is—length, 137; breadth. 46; altitude, 37 mm. The National Museum exhibits a specimen obtained in 70 fathoms 70 miles N.E. of the West Sisters Islands, Bass's Strait.

MITRA STADIALIS, Hedley.

1911. Mitra stadialis, Hedley. Zool., Commonwealth trawler "Endeavour," part I., p. 112, pl. 20, f. 37.

Hab.—Bass's Strait, Commonwealth trawler "Endeavour."

Obs.—Size of type: Length, 8.5; breadth, 3 mm.

MARGINELLA GATLIFFI, May.

1911. Marginella gatliffi, May. P.R.S., Tas., for 1910, p. 385, pl. 13, f. 8.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 3.3; breadth, 2.5 mm. The author remarks upon its resemblance to *M. ochracea*, Angas, and states, "but is a very much broader shell, with a shorter spire.". Colour, yellowish white.

MARGINELLA GABRIELI, May.

1911. Marginella gabrieli, May. Id., p. 386, pl. 13, f. 9.

Hab.—Dredged off Wilson's Promontory.

Obs.—Size of type: Length, 4; breadth, 2 mm. A biconical shell; white, with four orange bands. Our single specimen is slightly smaller.

DRILLIA SCHOUTANICA May.

1911. Drillia schoutanica, May. P.R.S., Tas., for 1910, p. 391, pl. 14, f. 17.

Hab.—Bass's Strait, Commonwealth trawler "Endeavour."

Obs.—Size of type: Length, 12.5; breadth, 5 mm.

DRILLIA SAXEA, Sowerby.

1896. Drillia saxea, Sowerby. P. Mal. Soc., Lond., vol. ii., p. 25, pl. 3, f. 4.

1909. Drillia saxea, Sowerby. Verco, T.R.S., S.A., vol. xxxiii., p. 304.

1911. Drillia saxea, Sowerby. May, P.R.S., Tas., for 1910, p. 308.

Hab.—Dredged off Wilson's Promontory.

Obs.—Size of type: Length, 7; breadth, 3 mm. Our single worn and bleached specimen is rather larger.

DRILLIA LACTEOLA, Verco.

1909. Drillia lacteola, Verco. T.R.S., S.A., vol. xxxiii., p. 304, pl. 26, f. 5.

1911. Drillia lacteola, Verco. May, P.R.S., Tas., for 1910, p. 308.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 4.8; breadth, 2.1 mm.

DRILLIA NENIA, Hedley.

1903. Drillia nenia, Hedley. Mem. Aust., Mus., vol. iv., p. 387, f. 101.

1909. Drillia nenia, Hedley. Verco, T.R.S., S.R., vol. xxxiii., p. 300.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 6.6; breadth, 2.5 mm. Compared by us with the type.

Genus Leucosyrinx, Dall, 1889.

LEUCOSYRINX RECTA, Hedley.

1903. Leucosyrinx recta, Hedley. Mem. Aust. Mus., vol. iv., p. 386, f. 99.

1911. Leucosyrinx recta, Hedley. May, P.R.S., Tas., for 1910, p. 308.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 6; breadth, 2.5 mm.

DAPHNELLA TRISERIATA, Verco.

1909. Daphnella triseriata, Verco. T.R.S., S.A., vol. xxxiii., p. 325, pl. 28, f. 8.

Hab.—Same as the preceding species.

Obs.—Size of type. Length, 4.6; breadth, 2.4 mm. The shell has seven unequal spiral lirae encircling the penultimate whorl, the intervening spaces being crowded with very fine axial striae, which ascend obliquely inclined to the right. Our identification has been kindly confirmed by Dr. Verco by comparison with his type.

NATICA SCHOUTANICA May.

1912. Natica schoutanica, May. P.R.S., Tas., p. 45, pl. 2, f. 3.

Hab.—Bass's Strait, Commonwealth trawler "Endeavour."

Obs.—Size of type: Diameter, major, 5.5, minor 4.5; height, 5 mm.

TURRITELLA MICROSCOPICA, May.

1911. Turritella microscopica, May. P.R.S., Tas., for 1910, p. 395, pl. 15, f. 23.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 3.5; breadth, 1 mm.

CAPULUS DEVOTUS, Hedley.

1904. Capulus devotus, Hedley. P.L.S., N.S.W., vol. xxix., p. 190, pl. 8, f. 15, 16.

Hab.—Same as the preceding species.

Obs.—Size attaining to: Height, 7; base, diameter, 7 mm.

CYCLOSTREMA HOMALON, Verco.

1907. Cyclostrema homalon, Verco. T.R.S., S.A., vol. xxxi., p. 305, pl. 29, f. 3, 4.

Hab.—Dredged off Wilson's Promontory.

Obs.—Size of type: Largest, diam., 2.7; smallest, 2; height, 1 mm.

CROSSEA NATICOIDES, Hedley.

1907. Crossea naticoides, Hedley. Rec. Aust. Mus., vol. vi., p. 290, pl. 54, f. 6, 7.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Height, 2.35; width, 3 mm. Shell smooth. "Umbilicus deep and narrow, its margin a faint basal funicle. Aperture entire, circular."

CROSSEA CARINATA, Hedley.

1903. Crossea carinata, Hedley. Mem. Aust. Mus., vol. iv., p. 345, f. 71.

Hab.—Same as the preceding species.

Obs.—Size of type: Height, 1.7; width, 1.8 mm. "Shell smooth and glossy. . . . Aperture subcircular."

Genus **Eglisia**, Gray, 1840.

EGLISIA TRIPLICATA, Tate.

1890. Scalaria (Eglisia) triplicata, Tate. T.R.S., S.A., vol. xiii., p. 231.

1892. Scalaria triplicata, Tate. Id. supp., pl. 9, f. 2.

1897. Eglisia triplicata, Tate. Harris, Cat. Tertiary Moll., B.M., part I. Australasian Tertiary Moll., p. 270.

Hab.—Port Albert (T. Worcester).

Obs.—Size of type: Length, 28; breadth, 7 mm. About one-half of our single specimen, being the earlier portion, is missing, the size of the remainder is: Length, 15; breadth, 6.5 mm. We have compared it with fossil specimens in the National Museum, obtained from Muddy Creek (Miocene), and consider it to be the same species. The palaeontologist, Mr. F. Chapman, concurs in this decision.

CINGULINA INSIGNIS, May.

1911. Cingulina insignis, May. P.R.S., Tas., for 1910, p. 396, pl. 15, f. 24, 24a.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 11.5; breadth, 2.8 mm.

TURBONILLA TIARA, May.

1911. Turbonilla tiara, May. Id., f. 25, 25a, 25b.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 9; breadth, 2 mm.

ODOSTOMIA NUGATORIA, Hedley.

1903. Odontostomia nugatoria, Hedley. Mem. Aust. Mus., vol. iv., p. 363, f. 87.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 2.2; breadth, 1 mm.

RISSOA IRAVADIOIDES, Gatliff and Gabriel.

1913. Rissoa iravadioides, Gatliff and Gabriel. Antea page 67.

Hab.—Dredged off Wilson's Promontory; also in 8 to 10 fathoms Western Port.

Rissoa janjucensis, Gatliff and Gabriel.

1913. Rissoa janjucensis, Gatliff and Gabriel. Antea page 67.

Hab.—Jan Juc, Puebla coast in shell sand; also dredged in 8 to 10 fathoms, Western Port.

Rissoa verconis, Tate; var. apicilata, Gatliff and Gabriel.

1913. Rissoa verconis, Tate var. apicilata, Gatliff and Gabriel. Antea page

Hab.—Dredged in 6 to 8 fathoms, Western Port; Port Albert (T. Worcester).

Rissoa wilsonensis, Gatliff and Gabriel.

1913. Rissoa wilsonensis, Gatliff and Gabriel. Antea page 68.

Rissoa rubicunda, Tate and May.

1900. Rissoia (Cingula) rubicunda, Tate and May. T.R.S., S.A., p. 100.

1901. Rissoia rubicunda, Tate and May. P.L.S., N.S.W., vol. xxvi., p. 393.

1902. Rissoia rubicunda, Tate and May. May, P.R.S., Tas., p. 114, f. 13.

1911. Amphithalamus rubicundus, Tate and May. Hedley, Zool., Commonwealth trawler "Endeavour," part I., p. 107.

Hab.—Western Port (T. Worcester).

Obs.—Size of type: Length, 2.5; breadth, 1 mm.

Rissoa pyramidata, Hedley.

1903. Scrobs pyramidatus, Hedley. Mem. Aust. Mus., vol. iv., p. 354, f. 77.

1911. Amphithalamus pyramidatus, Hedley. Zool. Commonwealth trawler "Endeavour," part I., p. 107.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 2.1; breadth, 1.4 mm.

Rissoa schoutanica, May.

1912. Rissoa schoutanica, May. P.R.S., Tas., p. 47, pl. 2, f. 6.

Hab.—Same as the last named.

Obs.—Size of type: Length, 2.5; breadth, 1.5 mm. Yellowish white. Body whorl encircled with three keels.

RISSOA FILOCINCTA, Hedley and Petterd.

1906. Rissoa filocincta, Hedley and Petterd. Rec. Aus. Mus., vol. vi., p. 217, pl. 37, f. 2.

1911. Rissoa filocincta, Hedley and Petterd. May, P.R.S., Tas., for 1911, p. 309.

Hab.—Same as the last named.

Obs.—Size of type: Length, 3; breadth, 1.7 mm. A very ornate species.

RISSOA AUSTRALIAE, Frauenfeld.

1867. Rissoa australiae, Frauenfeld. Novara, p. 14, pl. 2, f. 23.

1887. Rissoia australiae, Frauenfeld. Tryon, Man. Conch, vol., ix., p. 344, pl. 71, f. 81.

Hab.—Kilcunda.

RISSOA COLUMNARIA, Hedley and May.

1908. Rissoa columnaria, Hedley and May. Rec. Aust. Mus., vol. vii., p. 117, pl. 22, f. 9.

Hab.—Dredged off Wilson's Promontory.

Obs.—Size of type: Length, 2.6; breadth, 1.1 mm. Our examples only attain to about half this size, and the close longitudinal hair lines are less numerous.

Genus Phenacolepas, Pilsbry, 1891.

PHENACOLEPAS CALVA, Verco.

1906. Scutellina calva, Verco. T.R.S., S.A., vol. xxx., p. 217, pl. 8, f. 9, 10.

1912. Phenacolepas calva, Verco. Id., vol. xxxvi., pp. 185 and 199.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Height, 2; major diam., 2.8; minor diam., 1.8 mm.

LEPIDOPLEURUS COLUMNARIUS, Hedley and May.

1908. Lepidopleurus columnarius, Hedley and May. Rec. Aust. Mus., vol. vii., p. 123, pl. 24, f. 27, 28.

Hab.—Bass's Strait, Commonwealth trawler "Endeavour."

Obs.—Size of type: Length, 8; breadth, 3 mm. We have only the posterior and median valves, but the longitudinal radiating

rows of minute grains are so characteristic that the identification is readily made, and has been confirmed by us by comparison with the type.

ACANTHOCHITES KIMBERI, Torr.

1912. Acanthochites kimberi, Torr. T.R.S., S.A., vol. xxxvi., p. 167, pl. 6, f. 5a-f.

Hab.—Torquay.

Obs.—Size of type: Length, 10; breadth, 4 mm. We have compared our specimen with the type, which was kindly brought for examination by Dr. Torr, when he recently visited Melbourne. He concurred in our identification. The figure is correct in showing four tufts round the head plate, the description erroneously states that there are five. Our specimen has eight plates, but we can only see seven in the figure.

ACANTHOCHITES EXILIS, Torr and Ashby.

1898. Acanthochites exilis, Torr and Ashby. T.R.S., S.A., p. 218, pl. 7, f. 6.

Hab.—Dredged, Western Port.

Obs.—Size of type: Length, 3; breadth, 1mm. Dr. Torr has confirmed our identification, and states that "The whole shell is much more deeply coloured than the South Australian type, which is porcelain-white. The Victorian specimen is flesh-coloured (pinkish yellow), and the dorsal area of the third valve is not so brightly coloured as ours, yet it gives evidence of a deeper stain than the rest of the valves." Our single specimen measures 7 x 3 mm.

BULLINELLA PROTUMIDA, Hedley.

1903. Cylichna protumida, Hedley. Mem. Aust. Mus., vol. vol. iv., p. 396, f. 112.

Hab.—Dredged off Wilson's Promontory.

Obs.—Size of type: Length 5.4; breadth, 2.3 mm. May be distinguished readily from our other species by its being "inflated rather suddenly at the anterior third, rounded anteriorly, obliquely truncated at the vertex."

BULLINELLA PYGMAEA, A. Adams; var. SCULPTA, Gatliff and Gabriel.

1913. Bullinella pygmaea, A. Adams, var. sculpta, Gatliff and Gabriel. Antea page 69.

Hab.—Same as preceding species.

Dentalium virgula, Hedley.

1903. Dentalium virgula, Hedley. Mem. Aust. Mus., vol. iv., p. 328, f. 62.

1911. Dentalium virgula, Hedley. Verco, T.R.S., S.A., vol. xxxv., p. 209.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 10.5; breadth at aperture, 1.1., at apex 0.62; diameter of tube, 0.2 mm. Identification confirmed by us by comparison with the type.

Cadulus gibbosus, Verco.

1911. Cadulus (Polyschides) gibbosus, Verco. T.R.S., S.A., vol. xxxv., p. 213, pl. 26, f. 6.

Hab.—Same as preceding species.

Obs.—Size of type: Length, 9.7; greatest diameter 1.8; diam. of the posterior end, .45; of the anterior end, 1.1 mm. Our specimens are immature, but the identification has been confirmed by Dr. Verco.

Cadulus spretus, Tate and May.

1900. Cadulus (Gadilia) spretus, Tate and May. T.R.S., S.A., vol xxiv., p. 102.

1901. Cadulus spretus, Tate and May. P.L.S., N.S.W., vol. xxvi., p. 420, pl. 25, f. 52.

1903. Cadulus spretus, Tate and May. Hedley, Mem. Aust. Mus., vol. iv., p. 328.

1908. Cadulus spretus, Tate and May. Suter, Trans., New Zealand Inst., vol. xl., for 1907, p. 353.

1911. Cadulus spretus, Tate and May. Verco, T.R.S., S.A., vol. xxxv., p. 212.

Hab.—Same as preceding species.

Obs.—Size of type: Length, 5.5; diam. of larger aperture, .7; diam. of the smaller aperture, .3 mm. The type is in the Hobart Museum.

Cadulus angustior, Verco.

1911. Cadulus angustior, Verco. T.R.S., S.A., vol xxxv., pp. 211 and 218, pl. 26, f. 5, 5a, 5b.

Hab.—Port Albert (T. Worcester).

Obs.—Size of type: Length, 4.6; breadth, .6 mm. The author has kindly confirmed our identification. Narrower and more cylindrical than our other species.

Genus **Cuspidaria**, Nardo, 1840.

CUSPIDARIA BRAZIERI, E. A. Smith.

1867. Neaera (Rhinomya) rugata, Angas. P.Z.S., Lond., p. 914 (non A. Adams).

1885. Neaera brazieri, E. A. Smith. Chall. Zool., vol. xiii., p. 51, pl. 9, f. 3.

1902. Cuspidaria brazieri, E. A. Smith. Hedley, Mem. Aust. Mus., vol iv., p. 312.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size: Length, 6; height, 3.66; diameter, 2 mm.

CUSPIDARIA ALTA, Verco.

1908. Cuspidaria alta, Verco. T.R.S., S.A., vol. xxxii., p. 198, pl. 13, f. 8-11.

1912. Cuspidaria alta, Verco. May, P.R.S., Tas., p. 43.

Hab.—Same as last-named species.

Obs.—Size of type: Antero-posterior diam., 6.8; umbo-ventral. 4 mm.

Genus **Ectorisma**, Tate, 1892.

ECTORISMA GRANULATA, Tate.

1892. Ectorisma granulata, Tate. T.R.S., S.A., vol. xv., p. 127, pl. 1, f. 3, 3a.

1906. Ectorisma granulata, Tate. Hedley, P.L.S., N.S.W., vol. xxx., p. 539.

1907. Ectorisma granulata, Tate. Hedley, Rec. Aust. Mus., vol. vi., p. 302.

1911. Ectorisma granulata, Tate. May, P.R.S., Tas., for 1910, p. 311.

Hab.—Same as last-named species.

Obs.—Size of type: Antero-posterior diam., 15; umbo-ventral, 11 mm.

GARI MENKEANA, Reeve.

1856. Psammobia menkeana, Reeve. Conch. Icon., vol. x., pl. 6, f. 43.

Hab.—Portsea, Port Phillip.

Obs.—A small species, size of our largest example being: Antero-posterior diam., 19; umbo-ventral, 10 mm.

TELLINA DILUTA, Smith.

1885. Tellina diluta, Smith. Chall. Zool., vol. xiii., p. 108, pl. 4, f. 7-7b.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Length, 8; height, 5; diam., 2.5 mm. A white shell, concentric striae extending continuously from end to end.

CHIONE MESODESMA, Quoy and Gaimard.

1835. Venus mesodesma, Quoy and Gaimard, Astrolabe, vol. iii., part 2, p. 532, pl. 84, f. 17, 18.

1835. Venus spurca, Sowerby. Thes. Conch., vol. ii., p. 719, pl. 156, f. 92-98.

1880. Chione mesodesma, Quoy and Gaimard. Hutton, Man., New Zealand Moll, p. 148.

1885. Venus (Chamelaea) mesodesma, Quoy and Gaimard. Smith, Chall. Zool., vol. xiii., p. 131.

1905. Chione mesodesma, Quoy and Gaimard. Suter, P. Mal. Soc., Lond., vol. vi., p. 204.

1911. Chione mesodesma, Quoy and Gaimard. Hedley, Zool., Commonwealth trawler "Endeavour," part I., p. 100.

1912. Chione mesodesma, Quoy and Gaimard. May, P.R.S., Tas., p. 44.

Hab.—Dredged off Wilson's Promontory.

Obs.—Similar in appearance to *C. gallinula*, Lamarck, which has fine radial sculpture upon and between the concentric lamellae, a feature absent in the above-named species.

MERETRIX REGULARIS, Smith.

1885. Cytherea (Caryatis) regularis, Smith. Chall. Zool., vol. xiii., p. 140, pl. 1, f. 8-8b.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—It is variable in size, ranging from: Length, 5.5; height, 5; diameter, 4 mm., to length 10; height, 9 mm.

Genus Thyasira, Leach, in Lamarck, 1818.

THYASIRA FLEXUOSA, Montagu.

1801. Venus sinuosa, Donovan (non Pennant, 1777). British shells, vol. ii., pl. 42, f. 2.

1803. Tellina flexuosa, Montagu. Test, Brit., p. 72.

1815. Tellina flexuosa, Montagu. Wood, General Conch., vol. i., p. 188, pl. 47, f. 7, 8.

1818. Amphidesma flexuosa, Montagu. Lamarck, A.S.V., p. 492, who also quotes as a synonym Thyasira flexuosa, a name communicated to him by Leach.

1825. Tellina flexuosa, Montagu. Wood, Index Test., p. 22, pl. 4, f. 78.

1842. Thyatira flexuosa, Montagu. Sowerby, Conch. Man., 2nd ed., p. 274.

1857. Cryptodon flexuosus, Montagu. H. and A. Adams, Gen. Recent Moll., vol. ii., p. 469, pl. 114, f. 2, 2a.

1862. Crypton flexuosus, Montagu. Chenu, Man. Conch., vol. ii., p. 121, f. 583.

1875. Lucina (Cryptodon) flexuosa, Montagu. Woodward, Man. Moll., p. 456, pl. 19, f. 7.

1875. Axinus flexuosus, Montagu. Tate, Appendix Id., p. 72.

1884. Cryptodon flexuosus, Monft. (?). Tryon, Struct. and Syst., Conch., vol. iii., p. 211, pl. 119, f. 48.

1885. Cryptodon flexuosus, Montagu. Smith, Chall., vol. xiii., p. 192.

1895. Cryptodon flexuosus, Montagu. Brazier, P.L.S., N.S.W., vol. ix., for 1894, p. 725.

1895. Axinus flexuosus, Montagu. Pilsbry, Cat. Marine Moll. of Japan, p. 133.

1901. Thyasira flexuosus, Montagu. Dall, Proc. U.S. Nat. Mus., vol. xxiii., p. 784.

1901. Cryptodon flexuosum, Montagu. Tate and May, P.L.S., N.S.W., vol. xxvi., p. 431.

1902. Axinus flexuosus, Montagu. Hedley, Mem. Aust. Mus., vol. iv., p. 320.

1903. Thyasira flexuosa, Montagu. Dall, Trans. Wagner Free Inst., Phil., vol. iii., p. 1339.

1905. Cryptodon flexuosum, Montagu. Murdoch, Trans. New Zealand Inst., vol. xxvii., for 1904, p. 232.

1911. Thyasira flexuosa, Montagu. Dautzenberg and Fischer, Jour. de Conch., vol. lix., p. 42-47.

1912. Thyasira flexuosa, Montagu. Lamy, Bulletin du Mus. d'Hist. nat., Paris, No. 3, p. 5.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—In size the shell attains to about 9 x 9 mm. Our specimens are smaller, as also are others from Stewart Island, kindly sent to us by Mr. H. Suter, named *Thyasira flexuosa*, Montagu. The area of distribution of this species is very wide; it occurs in European, West Indian, Japanese and Australásian seas. Fossil in European Neocene and Pleistocene; and Tertiary, Florida, U.S.A.

Very many more references to the species could be cited; those given indicate the difficulty that is found in classifying these small shells, and the difficulty is enhanced when, as in this species, individual specimens vary considerably in form and size.

It may be questionable as to whether the name *Thyasira*, communicated by Leach to Lamarck, and attached to a named and well-known shell, his generic name apparently not having been previously published, is sufficient to establish the genus. Lamarck does not adopt it, but classes it in his genus *Amphidesma*, where it is misplaced.

CUNA EDENTATA Verco.

1908. Cuna edentata, Verco. T.R.S., S.A., vol. xxxii., p. 357, pl., 14, f. 1-3.

Hab.—Same as preceding species.

Obs.—Size of type: Antero-posterior, diam., 1.6; umbo-ventral, 1.9 mm. The shell much resembles *C. concentrica*, Hedley, but that species has the inner ventral margin crenulated; in the above species it is smooth.

CUNA COMMA, Verco.

1908. Cuna comma, Verco. T.R.S., S.A., vol. xxxii., p. 357, pl. 17, f. 29-31.

Hab.—Same as last-named species.

Obs.—Size of type: Antero-posterior, diam., 2.6; umbo-ventral, 3.2 mm. Obliquely pyriform. Concentrically ribbed. Inner ventral margin smooth.

CUNA CONCENTRICA, Hedley.

1902. Cuna concentrica, Hedley. Mem. Aust. Mus., vol. iv., p. 315, f. 55.

1908. Cuna concentrica, Hedley. Verco, T.R.S., S.A., vol. xxxii., p. 357.

1909. Cuna concentrica, Hedley. May, P.R.S., Tas., for 1908. p. 54.

Hab.—Torquay.

Obs.—Size of type: Height, 2; length, 1.85 mm. "Without radial sculpture, but with about forty concentric ribs." Sides triangular, ventral margin rounded. Equilateral.

CUNA ATKINSONI, T. Woods.

1877. Kellia atkinsoni, T. Woods. P.R.S., Tas., for 1876, p. 158.

1901. Carditella atkinsoni, T. Woods. Tate and May, P.L.S., N.S.W., vol. xxvi., p. 435, pl. 27, f. 107.

1902. Cuna atkinsoni, T. Woods. Hedley, Mem. Aust. Mus., vol. iv., p. 315.

1908. Cuna atkinsoni, T. Woods. Verco, T.R.S., S.A., vol. xxxii., p. 354.

1911. Cuna atkinsoni, T. Woods. Hedley, Zool., Commonwealth trawler "Endeavour," part I., p. 91.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Height, 3; width, 2 mm. A smooth shell.

CUNA PARTICULA, Hedley.

1902. Cuna particula, Hedley. Mem. Aust. Mus., vol. iv., p. 316, f. 56.

Hab.—Same as last-named species.

Obs.—Size of type: Height, 2; width, 2.3 mm. Concentrically sculptured; an oblique form. Inner ventral margin crenulated. Compared by us with the type. Our specimens attain to twice the size.

CARDITA CAVATICA, Hedley.

1902. Cardita cavatica, Hedley. Mem. Aust. Mus., vol. iv., p. 318, f. 58.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 17; height, 14; depth of single valve, 6 mm. We have compared our single valve with the type.

CARDITA DELICATA, Verco.

1908.—Venericardia delicata, Verco. T.R.S., S.A., vol. xxxii., p. 351, pl. 16, f. 18, 19.

Hab.—Same as last-named species.

Obs.—Size of type: Antero-posterior, diam., 8.5; umbo-ventral, 7.2 mm.

Nucula beachportensis, Verco.

1907. Nucula beachportensis, Verco. T.R.S., S.A., vol. xxxi., p. 216, pl. 27, f. 3.

Hab.—In about 40 fathoms, off Ninety Mile Beach.

Obs.—Size of type: Umbo-ventral, diam., 4.6; antero-posterior, 4.9 mm. "Is truncated or straight from the end of the hinge to the ventral border." Inner ventral margin minutely crenulate.

Leda fortis, Hedley.

1907. Leda fortis, Hedley. Rec. Aust. Mus., vol. vi., p. 362, pl. 66, f. 2, 3.

Hab.—Same as last-named species.

Obs.—Size of type: Height, 3.7; length, 4.2; depth of single valve, 1.45 mm. "Solid, smooth, nearly equilateral, sub-triangular, rather inflated."

Leda miliacea, Hedley.

1902. Leda miliacea, Hedley. Mem. Aust. Mus., vol. iv., p. 295, f. 43.

1907. Leda miliacea, Hedley. Verco, T.R.S., S.A., vol. xxxi., p. 217.

1911. Leda miliacea, Hedley. May, P.R.S., Tas., for 1910, p. 312.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 2.25; height, 1.5 mm. A minute ovate species. Our examples have been compared by us with the type.

Genus Cyrilla, A. Adams, 1862.

Cyrilla dalli, Hedley.

1902. Cyrilla dalli, Hedley. Mem. Aust. Mus., vol. iv., p. 296, f. 44.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 1.2; height, 1.05; depth of single valve, 0.35 mm. Compared by us with the type.

Modiola linea, Hedley.

1907. Modiola linea, Hedley. Rec. Aust. Mus., vol. vi., p. 300, pl. 56, f. 23-25.

1911. Modiola linea, Hedley. May, P.R.S., Tas., for 1910, p. 313.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 5.75; height, 2.5; depth of single valve, 0.9 mm. Compared by us with the type.

ARCOPERNA RECENS, Tate.

1897. Arcoperna recens, Tate. P. Mal. Soc., Lond., vol. ii., p. 181, three figures.

1900. Arcoperna recens, Tate. Hedley, P.L.S., N.S.W., vol. xxv., p. 496.

1901. Arcoperna recens, Tate. Tate and May, P.L.S., N.S.W., vol xxxvi., p. 439.

Hab.—Same as last-named species.

Obs.—Size of type: Transverse diameter of closed valves, 15; umbo-post-ventral, 19; antero-posterior, 17; umbo-ventral, 14 mm.

PHILOBRYA PECTINATA, Hedley.

1902. Philobrya pectinata, Hedley. Mem. Aust. Mus., vol. iv., p. 300, f. 46.

1911. Philobrya pectinata, Hedley. May, P.R.S., Tas., for 1910, p. 313.

Hab.—Same as last-named species; also in shell sand, Kilcunda.

Obs.—Size of type: Length, 2; height, 2.5 mm.

LIMA MURRAYI, Smith.

1891. Lima murrayi, Smith. P.Z.S., Lond., p. 444, pl. 35, f. 26.

1905. Limea acclinis, Hedley. Rec. Aust. Mus., vol. vi., p. 47, f. 10.

1906. Limea murrayi, Smith. Hedley, Id., p. 223.

1907. Limaea murrayi, Smith. Verco, T.R.S., S.A., vol. xxxi., p. 315.

Hab.—Same as last-named species.

Obs.—Size of type: Length, 8; height, 12; diameter, 6 mm.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913.]

Art. VIII.—*On Two New Species of Chaetogaster.*

By OLIVE B. DAVIES, M.Sc.

(Government Research Scholar, Melbourne University).

(With Plate IX).

[Read 12th June, 1913].

Introduction.

Chaetogaster is a genus of small, transparent worms, living on certain fresh-water snails, clinging to them by means of a posterior sucker, or as is sometimes found, crawling about right in the pulmonary chamber, into which it has worked it way through the pulmonary opening.

It does not seem to be confined to any one species of snail; I have found it on species of *Limnaea*, *Isidora* and on *Planorbis gilberti.*

On *Planorbis* it was quite abundant, and could be seen in the pulmonary chamber. This is worthy of note, as Dr. Annandale remarks of *C. bengalensis* that he saw "in one instance, in an aquarium in which snails were somewhat scanty, a solitary worm attempting to establish itself on a *Planorbis;* but the connection was only temporary, not lasting for more than a few minutes. The mouth of the shell in this genus is too constricted to be suitable for the worm, which is generally gregarious." On the other hand not only, as above remarked, did I find *C. australis* infesting species belonging to three genera of fresh water snails, but in some cases it even preferred *Planorbis* to either *Limnaea* or *Isidora*, when all three were present in the one jar.

The fact that the Australian *Chaetogaster* is found on these three genera is noteworthy. In Europe it is found on *Limnaea*, while here it is found on *Limnaea*, *Isidora* and *Planorbis*. In the same way in *Fasciola* the cercariae are found in Europe in *Limnaea*, while here they are found in several different genera; there is a question whether *Fasciola* has been introduced on some Limnaeae and spread here to other genera, and the same question, from analogy, may be raised with regard to *Chaetogaster*.

According to Beddard the genus *Chaetogaster* belongs to the Naidomorpha, a group of Oligochaetes which has already been recorded from Europe, America and Asia (India); but as far as I

can ascertain there has been no species of *Chaetogaster* hitherto recorded from Australia. During last year I found some of the pond snails I was keeping in vessels infested with this small parasite. These snails came originally from Merri Creek, Weeweerup, Yackandandah, and Geelong; and it is probable that the parasite also came from these several localities, as there does not seem to have been any possibility of infection between the separate jars. On examination there were found to be two species present. In most of the jars there was the form I shall describe as *Chaetogaster australis*, and this was present in very great numbers; but in one jar (from Merri Creek), and also on some snails in a pond in the University grounds, parasitic on a species of *Isidora* (*I. texturata*), were a few specimens of a much large species, which I shall describe as *Chaetogaster victoriensis*.

A great deal of the structure of *Chaetogaster* can be made out by examining the living animal, as it is very transparent. I also worked with sections, both transverse and longitudinal, and with preserved animals, stained and mounted whole. *Chaetogaster* is very difficult to kill satisfactorily, as it contracts rapidly and disintegrates very readily. The method I found most successful was to kill the animal by pouring on to it boiling 70 per cent. absolute alcohol. This acts as a fixing and preserving agent. I used several different stains; the most satisfactory were methyl blue for staining whilst alive, borax carmine for the specimens mounted whole, and acetic acid alum carmine for the sections.

Chaetogaster australis, sp. n.

External Characters.

Length.—The length varies from 0.88 mms. to 1.83 mms. Average individuals measure about 1.4 mms. The largest measured (1.83 mms.) was almost divided.

The prostomium is circular and sucker-like; this is most clearly seen in the living animal, which moves along with a looping movement, very much like a leech. The mouth is on the ventral surface; the anus is terminal. At the posterior end there is no definite sucker, but the animal seems capable of slightly flattening its body so as to somewhat resemble one.

The setae are arranged in bundles; typically there is a pair of bundles of setae in each segment; but after the first pair there is an interval without any setae; the second pair of bundles is in the sixth segment. Then they are arranged regularly, a pair in each segment, to the posterior end.

Dorsally there are little papillae, each with two or three fine short hairs; these are probably sensitive, and are only clearly seen when the living animal is treated with some foreign substance such as methyl blue. There are also a number of coarser hairs round the anterior and posterior ends.

There is no clitellum.

Asexual reproduction, by means of fission, is a marked characteristic of this animal; but in this species I could find no case of secondary fission as described in other species.

Segmentation.

Segmentation is marked externally by the setae; there being typically a pair of bundles of setae in each segment, but the second bundle marks the sixth segment, there being an asetigerous portion between the first and second bundle. The posterior segments are shorter than the anterior, and, consequently, the setae are closer together.

Internally segmentation is marked by the septa, and the ganglia of the ventral nerve cord. The number of segments varies, as new ones are constantly being added. Asexual reproduction takes place in consequence of this. The shortest animal I met with consisted of eleven segments.

In eighteen specimens examined:—

2	having	19	segments,	the	line	of	fission	was	between	10	and	11
1	,,	15	,,	,,	,,	,,	,,	,,	,,	11	,,	12
3	,,	15	,,	,,	,,	,,	,,	,,	,,	9	,,	10
3	,,	14	,,	,,	,,	,,	,,	,,	,,	9	,,	10
6	,,	13	,,	,,	,,	,,	,,	,,	,,	9	,,	10
1	,,	12	,,	,,	,,	,,	,,	,,	,,	8	,,	9
1	,,	12	,,	was not dividing.								
1	,,	11	,,	,,	,,	,,						

The above list seems to point to the formation of new segments on each side of the line of fission, and not only in the posterior segments, though the new segments seem to be formed more rapidly at the posterior end.

Setae.

The setae, as has been stated before, are arranged in bundles, and there are typically a pair of bundles in each segment. Each bundle is placed ventro-laterally, and consists of from 8 to 11 setae, arranged in a semi-circle (Fig. vi. C.), except in the first bundle, which is straight. (Fig. vi. B.) In connection with these setae

there are strong muscles so arranged that the setae are capable of rotary movement or up and down, or they can spread out like a fan. The setae of the first bundle are longer than those of the others, being approximately half as long again; they are situated at the level of the pharynx, while the second are at the level of the hinder end of the crop. Each seta is somewhat *f* shaped, bifurcated at one end, with two unequal prongs, and a swelling near the middle. (Fig. vi. A.) There are no dorsal setae.

Body Cavity.

The body cavity is divided up by the septa into segments. The septa are more clearly distinguished towards the anterior end, and by their aid we find the portion without setae consists of three segments. (Fig. i.). Each septum is very thin, with here and there a slight swelling caused by nuclei. The first septum is behind the pharynx, the second at the beginning of the crop, the third and fourth in the region of the crop, and the fifth at the posterior end of the crop. (Fig. i.)

I could not see any corpuscles in the body cavity.

Alimentary Canal.

The mouth, which is large and circular, opens on the ventral surface; the buccal cavity is somewhat globular anteriorly, but narrows posteriorly; (Fig. iv. BC) it is lined with indefinite cells without any clear nuclei, and its walls are very much strengthened by muscle bands.

The pharynx (Fig. iv. P.) is a wide tube leading from the buccal cavity to the oesophagus. Its walls are also very muscular. It extends back to the third segment.

After this the canal narrows to form the oesophagus (Fig. iv. O.; Fig. i. O.), lying in the third segment. This differs from the pharynx in being of much smaller size, not so muscular, and in having its inner lining thrown into more folds. The buccal cavity, pharynx, and oesophagus are, all three, attached to the body wall by numerous strong muscle bands.

The canal then, in the fourth, fifth and sixth segments, forms another dilatation, the crop. (Figs. i and iv. C.) This is about twice as long as the pharynx, is not attached to the body wall by well-defined muscle bands, and contains little muscular tissue, but has little blocks of muscle round the outside of its walls, and is lined by large distinct glandular cells, with very distinct nuclei and nucleoli. (Fig. iv. C.)

The stomach (Fig. i. S.) is marked off from the crop by a very definite constriction. The stomach and intestine (Fig. i. I.) are not clearly distinguishable in prepared specimens, but in the living animal the stomach can be distinguished by its refractive particles. Their walls are more muscular than those of the crop, and the lumen much smaller owing partly to the greater development of the lining cells. These cells are not nearly so distinct as in the crop, and their nuclei are not so clear. The stomach occupies the seventh and eighth segments, and the intestine runs from this to the posterior end, where the anus opens to the exterior.

Circulatory System.

The blood is colourless and has no corpuscles. There is a distinct dorsal contractile vessel running from behind forwards; its pulsations are very noticeable just about the junction of the oesophagus and the crop. Here it appears to form a dilatation, and a little in front of this a vessel runs down either side of the oesophagus, and the two unite to form a ventral vessel.

Excretory System.

The excretory system consists of paired nephridia. They are constantly found in the seventh and eighth segments (Fig.i. N.), and often in the tenth and eleventh, and sometimes immature ones more posterior still. They are not found in the newly-formed segments. The openings of the nephridia to the exterior are situated immediately in front of the bundle of setae of the same segment. Following back from the opening to the exterior, is a diverticulum, and beyond this a dilatation, then follows a coiled tube, which ends in a swelling near to the anterior septum of the segment, to which it seems to be attached by muscle fibres. (Fig. vii. A.)

Nervous System.

The nervous system consists of a dorsal cerebral ganglion (Fig. i. C.G.); from this nerve commissures run round either side of the alimentary canal to a ventral ganglion. Running from this there is, typically, a ventral nerve cord (Fig. i., N.C.), with a ganglion in each segment; but in the anterior segments the nerve cord is double; and in the asetigerous portion the ganglia somewhat irregular and ill-defined.

Reproductive System.

I could not discover any trace of reproductive organs in any specimen I examined. Asexual reproduction is, however, very common; in fact, a normal individual without any trace of fission is not at all common.

Asexual Reproduction.

Mr. H. Seddon, L.V.Sc., of the Veterinary School, and Mr. J. Brake, B.Sc., of the Biology School, were good enough to take some micro-photographs of *C. australis* during fission, and drawings from these are reproduced in Figs. viii. to xvi.

Normally, asexual reproduction begins to take place when the animal consists of about 12 segments. But actual fission does not take place till more segments have been added on each side of the line of fission. The process may be artificially hastened, is not actually brought about by heat, scarcity of water, or treatment with some foreign material, e.g., methyl blue in small quantities, or some other water stain, if very dilute solutions are used; if the solution be too strong, or the water begins to dry up through evavoration too quickly, the animal disintegrates at once. This had to be borne in mind while the photographs were being taken, and plenty of water given the animals.

The first indication that fission is about to take place, is a thickening and wrinkling of the body wall about the region of the eighth segment. At the same time outgrowths from the ventral nerve cord grow up either side of the alimentary canal, under the thickening, about the line of future fission, and finally form a nerve ring round the alimentary canal. The thickening is at first fairly wide (Fig. viii.), but later it narrows to form just a line across from side to side. For a long time the animal remains at this stage, indicated in Figs. x and xi.; this almost has the appearance of disintegration, but the actual animal these photographs were taken from divided after this stage, and formed two new individuals very like those represented in Fig. xvi. With regard to the organs, the canal becomes differentiated to form the new parts of the new individuals. That is, the intestine of the original individual lengthens, and finally becomes divided and differentiated to form the whole canal of one of the new individuals; and the stomach of the original individual, with a small part of the intestine, lengthens, and finally becomes stomach and intestine of the second new individual; so for a time the mouth and the anus of the two new individuals are in

contact. In Figs. xi. and xiv. it seems as if these organs actually function as such before complete fission takes place.

The nerve ring is formed by the outgrowths from the nerve cord, which have already been mentioned. New setae are formed very quickly. I was not able to make out the method of their formation. The nephridia are not formed until some time later. The portion between the first two bundles of setae after the line of fission lengthens out rapidly, and finally after the animal has been lying quiescent for some time, it gives a series of rapid contractions, and the two new individuals jerk themselves apart.

Figs. xii. and xiii. show an individual in which the line of fission is narrowing down.

Fig. xiv. shows another individual at the stage represented in Fig. x. This individual also divided afterwards.

Fig. xv. shows a stage between those represented in Figs. viii. and ix. Fig. xvi. shows two new individuals immediately after fission.

Chaetogaster victoriensis, sp. n.

External Characters.

Length.—The length varies from 6 to 9 mms. Average individuals measure about 8 mms.

The animal is much larger than *C. australis;* it is less inclined to disintegrate, contains more segments, and, consequently, the asetigerous portion seems comparatively shorter.

There is no clitellum.

C. victoriensis, like *C. australis*, reproduces asexually by fission, but differs in that in this species secondary fission takes place as a rule, before the primary fission is complete.

The prostomium is circular, the mouth ventral, the anus terminal. The setae are arranged in bundles as in *C. australis*. There are some fine hairs round the two ends of the animal.

An average animal consists of about 20 segments. I could find no individual in this species that had no trace of fission; in fact, each specimen not only showed signs of primary fission, but of secondary as well.

Movement takes place by means of a series of contractions and expansions with the aid of anterior and posterior suckers, somewhat like a leech.

The setae are arranged in bundles, and there are typically a pair of bundles in each segment. There is also the asetigerous portion followed by the bundle in the sixth segment. Each bundle consists of from 5 to 9 setae.

Segmentation.

Segmentation is marked externally by the setae, internally by the septa, nephridia and ganglia of the ventral nerve cord. The number of segments varies; the individuals I observed consisted of from 16 to 25 segments.

Setae.

The setae of the first bundle are longer than those of the others. Each seta is of the same general shape as in *C. australis*, but is much longer in comparison to the difference in the size of the animals, and the forked end is much shorter. There are also fewer in each bundle than in *C. australis*.

Body Cavity.

The body cavity is divided by the septa into segments. The septa are more clearly distinguished towards the anterior end. The first septum is behind the pharynx, the second behind the oesophagus, the sixth behind the crop, the ninth behind the stomach. (Fig. ii.)

Alimentary Canal.

The mouth (Fig. ii. M.) is large and circular; it is situated on the ventral surface, and opens into the buccal cavity (Fig. ii. B.C.), which leads to the pharynx. (Fig. ii. P.)

The pharynx is extremely muscular, and is attached to the body wall by muscle bands.

The oesophagus (Fig. ii. O.) is short and narrow, and leads into a large, thin walled sac, the crop (Fig. ii. C.), the walls of which appear to be only one cell thick.

A well-marked constriction separates the crop and stomach.

The stomach (Fig. ii. S.), lying in the seventh, eighth, and ninth segments, is better defined than in *C. australis;* it is a dilatation of the alimentary canal not so wide as the crop, and narrowing posteriorly to pass into the intestine (Fig. ii. I.), which runs to the anus.

Circulatory System.

The blood is colourless, and has no corpuscles. The course of the blood vessels is similar to that in *C. Australis*.

Excretory System.

The excretory system consists of a number of paired nephridia, and there are typically a pair of these in each segment. (Fig. ii. N.) They generally commence in about the seventh segment, being

absent in the more anterior ones. From this backwards there appears to be a pair in each segment, except in those segments across which future fission takes place. Here it would be hard to distinguish them if they were present, owing to the thickening of the body wall, and the outgrowths from the ventral nerve cord.

The openings of the nephridia to the exterior are situated immediately in front of the bundles of setae of the same segment; following back from this opening is a dilatation, and back from this a much coiled tube ending in a large swelling. (Fig. vii. B.)

Nervous System.

The nervous system consists of a dorsal bilobed cerebral ganglion (Fig. iii. C.G.); from this two stout commissures run down either side of the pharynx, and from a bilobed ventral ganglion (Fig. iii. A.V.G.); from this the ventral nerve cord (Fig. iii. N.C.) runs down, with typically a ganglion in each segment; but in the anterior segments the ganglia are somewhat irregular, and the nerve cord and ganglia are double. This is clearly seen in Fig. iii.

Reproductive System.

I could not discover a trace of reproductive organs in any specimen I examined. The animal reproduces asexually by fission; but it seems to be a much slower process than in *C. australis*. Also secondary fission before primary is complete seems to be the rule in this species. (Fig. ii. L.F.2.)

It is doubtful whether these species of Chaetogaster are truly parasitic. In some individuals small crustaceans were found in the alimentary canal, but in others it was almost empty. The fact that specimens were found in the pulmonary chamber also indicates that there may be another mode of nutrition. It certainly seemed to cause the death of a great many snails in my vessels; but this may have been due to suffcation by the blocking up of the pulmonary chamber and its opening by the worms. Some of the European species are said to be internal parasites, but most others seem to use the snail more as a means of progression and as a shelter.

C. australis appears to most resemble *C. bengalensis*. It differs from it in the number of its setae in each bundle, and their different arrangement; in its much smaller size and in several minor characteristics; *C. australis* also has a preference for crawling right into the pulmonary chamber of the snail rather than staying on the outside.

C. victoriensis appears very different. It resembles *C pellucidus* and *C. punjabensis*, etc., in secondary fission. It is much larger than *C. punjabensis*, and a little larger than *C. pellucidus*, being nearest *C. bengalensis* in this respect.

A very marked feature in *C. victoriensis* is the fact that the anterior portion of the nervous system is completely double (this is clearly seen by reference to Fig. iii.), while in *C. australis* only the cord itself is double.

In *C. victoriensis* I could not see any of the dorsal papillae and hairs as in *C. australis*. Both *C. australis* and *C. victoriensis* resemble *C. filiformis* in the absence of the dilatations of the oesophagus.

I should now like to thank Professor Spencer and Dr. Hall, under whom this work has been undertaken, for all their help and advice.

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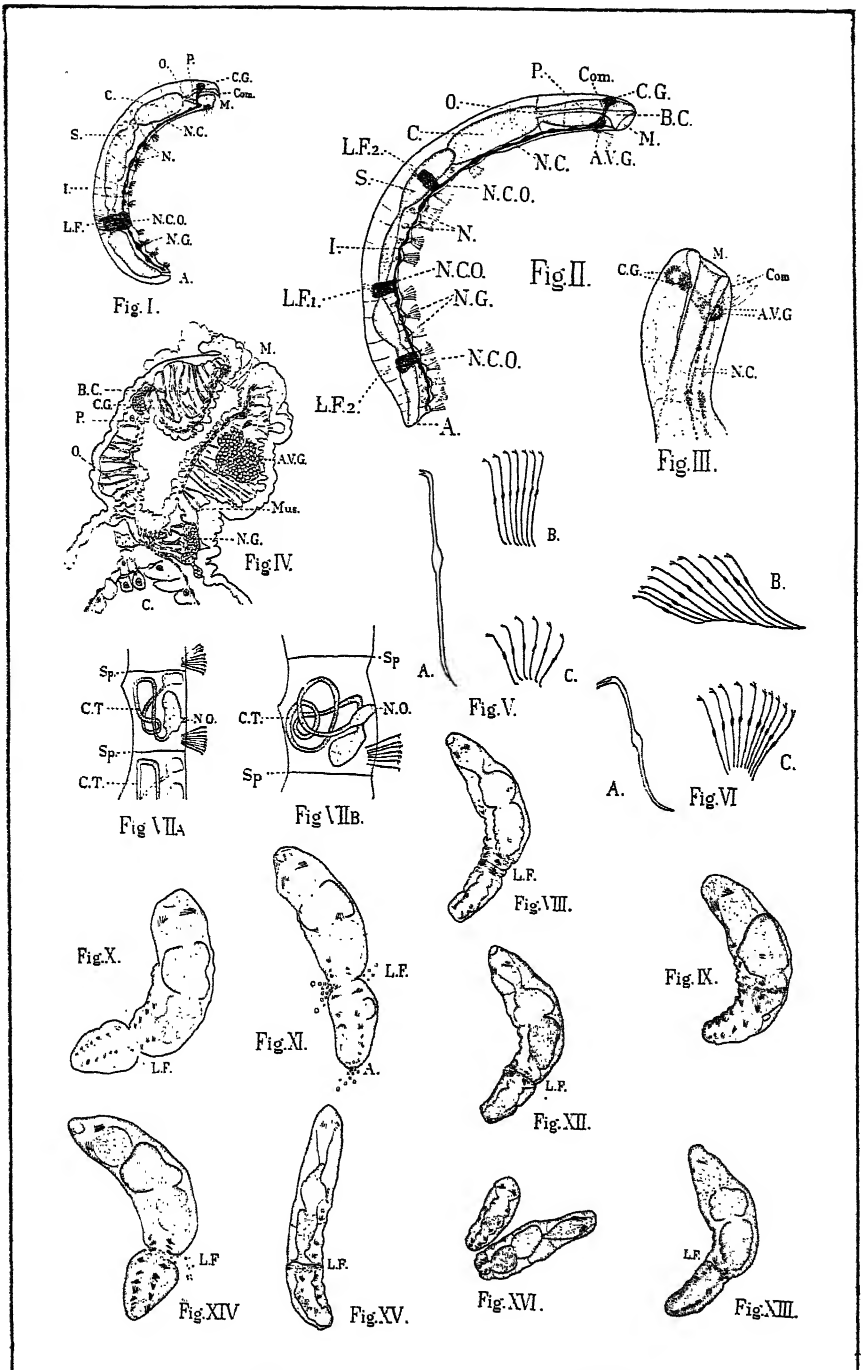
EXPLANATION OF PLATES.

In all figures :—

A.	Anus.
A.V.G.	Anterior ventral ganglion.
B.C.	Buccal cavity.
C.	Crop.
C.G.	Cerebral ganglion.
C.T.	Coiled tube.
Com.	Commissure.
I.	Intestine.
L.F.	Line of fission.
L.F.1.	Primary line of fission.
L.F.2.	Secondary line of fission.
M.	Mouth.
Mus.	Muscle.

N.	Nephridium.
N.C.	Nerve cord.
N.C.O.	Outgrowth from nerve cord.
N.G.	Nerve ganglion.
N.O.	Opening of nephridia to the exterior.
O.	Oesophagus.
P.	Pharynx.
S.	Stomach.
Sp.	Septum.
Fig. i.	C. australis (living animal).
Fig. ii.	C. victoriensis (living animal).
Fig. iii.	C. victoriensis, head.
Fig. iv.	C. australis, longitudinal section of anterior portion.
Fig v	C. victoriensis, setae } A. Typical seta. B. Anterior group of setae. C. A typical group of setae.
Fig. vi.	C. australis, setae.
Fig. vii.a	C. australis, nephridium.
Fig. vii.b	C. victoriensis, nephridium.
Figs. viii.-xi.	C. australis, different stages in the division of an individual A.
Figs. xii.-xiii.	C. australis, division of an individual B.
Figs. xiv.-xvi.	C. australis, stages in the division of three individuals C, D, E.


O.
P.
C.G.
Com.
M.
C.
S.
N.C.
N.
I.
L.F.
N.C.O.
N.G.
A.
Fig. I.
P.
Com.
C.G.
O.
B.C.
M.
C.
L.F.2.
N.C.
A.V.G.
S.
N.C.O.
N.
I.
N.C.O.
Fig. II.
L.F.1.
N.G.
N.C.O.
L.F.2.
A.
C.G.
M.
Com
A.V.G
N.C.
Fig. III.
M.
B.C.
C.G.
P.
O.
A.V.G.
Mus.
N.G.
Fig. IV.
C.
B.
B.
A.
C.
Fig. V.
Sp.
C.T.
N.O.
Sp.
C.T.
Fig VIIA
Sp
C.T.
N.O.
Sp
Fig VIIB.
A.
C.
Fig. VI
L.F.
Fig. VIII.
Fig. X.
L.F.
L.F.
Fig. XI.
A.
L.F.
Fig. XII.
Fig. IX.
L.F
Fig. XIV
L.F.
Fig. XV.
Fig. XVI.
L.F.
Fig. XIII.

[PROC. ROY. SOC VICTORIA, 26 (N S.), PT. I, 1913].

ART. IX.—*New or Little-known Victorian Fossils in the National Museum.*

PART XVI.—SOME SILURIAN BRACHIOPODA.

BY FREDERICK CHAPMAN, A.L.S., F.R.M.S.
(Palaeontologist to the Museum).

(With Plates X. and XI).

[Read 12th June, 1913].

Introduction.

The fauna of the Victorian Silurian strata includes a rich assemblage of brachiopods; and although the number in this group, together with the present contribution, now amounts to about 60 species, yet probably not more than half has been described.

A selection of the better preserved specimens has been studied, and the results, given herewith, help to show how interesting is the Australian Silurian fauna compared with that of other widely separated areas. One feature of the present series is the marked Devonic element found in the otherwise Wenlockian or newer Silurian facies of our Yeringian mudstones.

Amongst the more noticeable points brought out by the present work is the presence of a denticulate hinge in *Leptaena rhomboidalis*, especially in shells of the younger or neanic stage, a structure hitherto unknown in this genus. The wonderfully well-preserved impression of the brachial arms in the same species of *Leptaena* is also figured and described here for the first time from Australian rocks; and the brachial supports of one of the specimens tends to show affinity with the chonetine structures in similar valves of the Productidae.

For some of the fossiliferous material included in the present paper the writer is indebted to Mr. W. S. Dun, F.G.S., of Sydney, who, some years ago undertook to describe Mr. G. Sweet's collection of Silurian fossils, but who, after my arrival in Australia, generously and insistently passed on the collection to be worked out in the National Museum by myself. Consequently upon this, Mr. Sweet has consented to donate the described specimens as they are dealt with from time to time.

List of genera and species herein described :—

Siphonotreta plicatella, sp. nov.
Crania pulchelloides, sp. nov.
Leptaena rhomboidalis, Wilckens sp.
Leptaena rhomboidalis, var. *undata*, McCoy.
Chonetes bipartita, sp. nov.
Conchidium knightii, J. de C. Sowerby
Clorinda linguifera, Sow. sp. var. *wilkinsoni*, Etheridge fil.
Gypidula victoriae, sp. nov.
Atrypa reticularis, Linné sp., var. *decurrens*, var. nov.
Atrypa aspera, Schlotheim sp.
Atrypa fimbriata, sp. nov.
Cyrtina sub-biplicata, sp. nov.
Spirifer lilydalensis, sp. nov.

SYSTEMATIC DESCRIPTION OF THE FOSSILS.

Class BRACHIOPODA.

Fam. SIPHONOTRETIDAE.

Genus **Siphonotreta**, de Verneuil.

Siphonotreta plicatella, sp. nov. Plate X., figs. 1*a-c*.

Description.—Pedicle valve subrectangular, transverse; posterior margin broadly convex, cardinal angles rounded; anterior margin nearly straight, with a median sinus. Pedicle opening close to posterior margin, apical, and communicating with a short, open channel directed anteriorly; a median wrinkle denotes the position of the underlying pedicle tube. Shell folded into three areas, two postero-lateral depressed-convex areas, and an anterior median and sunken area. Surface ornament consisting of concentric laminar folds and vertical striae; the latter probably representing remnants of short, spinous processes; also a few corroded and broken tubular cavities with jagged edges pointing to the former presence of several long spines.

Measurements.—Holotype. Length, 3.5 mm.; width, 5 mm.; height, approximately, 1 mm.

Observations.—The present species is definitely placed in the above genus, *Siphonotreta*, on account of the apical foramen and spinous character of the shell. The transverse character of the outline is somewhat peculiar for *Siphonotreta*, but this may be almost matched in some varieties of *S. australis*, Chapman,[1] from the

[1] Proc. Roy. Soc. Victoria, vol. xvi. (n.s.), pt. i., 1903, pp. 65, 66, pl. x., figs. 7, 8, 13; pl. xi., fig. 1.

Silurian (Melbournian) of South Yarra, Victoria. In outline *S. plicatella* very nearly resembles Barrande's "*Discina*" *plicosa*[1] from stages F and G (Lower Devonian) of Branik and Konieprus in Bohemia. That form, however, is a true *Orbiculoidea*, having a posterior foramen, as well as merely finely concentric ornament.

Occurrence.—Silurian (Yeringian). In grey mudstone: Yan Yean, Victoria. Presented by A. J. Shearsby, Esq., F.R.M.S.

Fam. Craniidae.

Genus Crania, Retzius.

Crania pulchelloides, sp. nov. Plate X., figs. 2*a*, *b*.

Description.—Shell small, subpentagonal, slightly wider than long (length measured post-anteriorly). Free valve depressed limpet-shaped; the apex situated a little towards the posterior margin. Posterior margin short, straight, rather sharply angulated at the extremities; thence the margin slopes steeply towards the rounded and broad anterior margin. Surface of free valve furrowed with concentric growth-lines and depressions, and having a variable series of moderately-fine radial riblets converging to the apex. Between the primary sharp and salient riblets there is a second system of fine striae, commencing some distance from the vertex, and extending to the margin of the valve.

Measurements.—Length, 4.5 mm.; width, 5.25 mm.; approximate height, 2.5 mm.

Observations.—Undoubtedly the nearest allied form to the above is *Crania pulchella*, Hall and Clarke,[2] a species occurring in the Lower Heidelberg, near Clarksville, New York State. The shell is larger and more rotund in outline than *C. pulchelloides*. None of the British species appear to approach the Australian form here described.

Occurrences.—Found occasionally in the Silurian (Yeringian) mudstone in the neighbourhood of Lilydale. Holotype (from Ruddock's Quarry) presented by W. J. Parr, Esq.

Fam. Strophomenidae.

Genus Leptaena, Dalman.

Leptaena rhomboidalis, Wilckens sp. Plate X., figs. 3-7.

Conchites rhomboidalis, Wilckens, 1769, Nachricht von seltenen Versteinerungen, vorzüglich des Thierreichs, p. 79, pl. viii., figs.

1 Syst. Sil. Bohême, vol. v., 1879, pl. ci., figs. ii., 1-7.
2 Pal. N. York, vol. viii., Pal. Brach., pt. i., 1892, p. 180, pl. ivH., fig. 3.

43, 44. *Leptaena depressa*, Sowerby, 1839, in Murchison's Silurian System, pp. 623, 636, pl. xii., fig. 2. *Strophomena rhomboidalis*, Wilckens sp., Davidson, 1871, Mon. Sil. Brach (Pal. Soc.), pt. vii., pt. vii., No. 4, p. 281, pl. xxxix., figs. 1-21; pl. xliv., fig. 1. *Leptaena* (*Leptagonia*) *rhomboidalis*, Wilckens sp., McCoy, 1877, Prod. Pal. Vict., Dec. V., p. 19, pl. xlvi., fig. 1.

Observations.—As McCoy has remarked, the Victorian specimens of *L. rhomboidalis* show no difference from the European examples, and exhibit the same variable characters. The species is a very abundant fossil in certain of the mudstone facies of the newer or Yeringian division of the Victorian Silurian, some fossiliferous blocks being quite crowded with their remains to the exclusion of other shells. Three very interesting examples of this species having an important bearing on the phylogenetic relationship of this group, were discovered in the mudstone at Loyola, near Mansfield, by Mr. Geo. Sweet, F.G.S., and these are described below.

Note on a specimen of Leptaena rhomboidalis showing striate denticulations on the cardinal area. (Plate X., fig. 3.)

Hitherto the hinge-line of *Leptaena depressa* has been held to have a non-denticulate character. Amongst the well-preserved casts of this shell in the Sweet collection, however, there is one specimen in the neanic stage,[1] 13.75 mm. wide, showing the cardinal line, especially on the portions nearest to the cardinal process of the opposed brachial valve, to have fine but well-marked linear ridges normal to the hinge margin.

In Hall and Clarke's summary of characters in the genus *Leptaena*[2] those authors say "Cardinal area narrow, slightly wider on the pedicle valve, not denticulate." It is conceivable that these denticulae now recorded may be only partially calcified as a rule, and thus similar to other structures only occasionally seen in this genus, such as the spiral brachia, and the striated muscular areas, and that the process of fossilisation more often tends to their disappearance than to their preservation. Another reason to be assigned for this denticulate structure hitherto escaping observation is that the usual condition of the matrix is more or less calcareous, and this tends towards a secondary mineralisation of the fossil body; whereas the mudstone of the Victorian Silurian lends itself admirably to the preservation of delicate organic structures such as this. In fact, the fine, oozey mud which was laid down in those times was to

1 That is, a young form developing the adult characters of the shell.

2 Pal. N. York, vol. viii., Pal. Brachiopoda, pt. i., 1892, p. 277.

all intents and purposes comparable to a colloid substance, and took an instantaneous impression of the intricate structural features of the organism before they became deteriorated by agents of decay.

Note on a brachial valve of Leptaena rhomboidalis showing well-preserved impressions of the brachial spiralia.
(Plate X., figs. 4, 5.)

This shell is in the early neanic stage, and measures only 5 mm. in length by 7.5 mm. in width. It represents the interior of a brachial valve with the fleshy spiralia strongly impresesd on the surface. The positive form of the spiralia is seen in the wax impression. It shows them to have been apparently diplospiral,[1] but of few convolutions, the apices directed to the front (ventrally) and slightly outwards. That this specimen is the interior of a brachial valve and not merely the impression in mudstone is evident from the fact that true shell structure is present by the distinct perforations all over the internal surface. The cardinal area is very distinctly crenulate, more strongly so than in the neanic form herewith figured to illustrate this new character in *Leptaena* (Fig. 3). These points tend to support the suggestion here brought forward that the denticulate hinge character disappears with age and shell-development, owing perhaps to the greater strength acquired in later stages by the formation of the dental lamellae adjacent.

The form of the spiralia, so clearly demonstrated by a wax impression, is even more definite than in the beautiful example of the Gothland specimen figured by Davidson.[2] Moreover, in our example the spires are seen to be attached directly to the crura at the posterior end of the septum.

Note on a brachial valve of Leptaena rhomboidalis showing brachial markings or supports. (Plate X., figs. 6, 7.)

This specimen, discovered by Mr. Sweet, is also, as in the former example, in the neanic stage. It is a very faithful mud-cast of the interior of the brachial valve. The crenulation of the cardinal area is very distinct. The septum is well developed, extending nearly the whole length of the shell. The bases of the brachial supports follow the general trend of the spiralia, but show a curious angularity of outline towards the anterior margin; a character

1 A double spire formed by the continuity of the bifurcated jugum with the convolutions of the spire. In this particular case the continuation of the jugal processes was probably of a chitinous nature.

2 Op. cit., pl. xxxix., fig. 16.

seen in *Chonetes* and *Strophalosia*, to which this genus, at least in its young stages, shows marked affinities. It is more than probable from the above structural features that *Leptaena* is of a more advanced type of the Strophomenidae, which shows retrogressive tendencies in its later development.

Occurrence.—The above species, *L. rhomboidalis*, has been recorded from one doubtful Melbournian locality, Fraser's Creek, Springfield; otherwise, it is restricted in Victoria to the Yeringian stage, occurring at Lilydale, Croydon, Loyola and the Thomson River. It also occurs in the passage beds (between Melbournian and Yeringian) at Whittlesea.

The unique specimens showing the spiralia and brachial supports, as well as the example with finely denticulate hinge-line, were found by Mr. Geo. Sweet, F.G.S. at Loyola, near Mansfield, who has presented them to the Museum.

Leptaena rhomboidalis, Wilckens sp.; var. undata, McCoy.

Orthis undata, McCoy, 1846, Syn. Sil. Foss., Ireland, p. 136, pl. iii., fig. 1. *Leptaena deltoidea* Conrad, var. undata, McCoy, 1852, Brit. Pal. Foss., p. 234, pl. 1H., figs. 38, 39. *Strophomena deltoidea*, Conrad sp., var. *undata*, McCoy, Davidson, 1871, Mon. Sil. Brach. (Pal. Soc.), pt. vii., No. 4, p. 295, pl. xxxix., figs. 23, 24. *L. rhomboidalis*, Wilckens sp. var. *undata*, McCoy, Chapman, 1907, Vict. Nat., vol. xxii., p. 239.

The characteristic ripple-surfaced shell of the above form is met with in various stages of development, from 35 to nearly 100 mm. in width, in the Victorian Silurian. It appears to keep tolerably distinct from *L. rhomboidalis* by its more transverse shape, larger size and irregular and persistently wrinkled surface; and it may therefore be regarded as a tolerably well-marked variety of *L. rhomboidalis*.

Occurrence.—Silurian (Yeringian). Loyola, near Mansfield, in hard, brown and grey mudstone. Collected by Geo. Sweet, Esq., F.G.S.

Fam. Productidae.

Genus Chonetes, Fischer.

Chonetes bipartita, sp. nov. Plate X., figs. 8-10.

Description.—Shell small, semicircular or transverse. Pedicle valve strongly convex; median area conspicuously arched and medially sulcate; beak prominent; area on either side of median

ridge depressed and concave towards the cardinal extremity. Hinge line straight, extremities acute and more or less extended; anterior margin regularly and broadly rounded. Brachial valve concave, with two divergent folds or flexures of the shell-surface. Surface of both valves punctate, bearing about 30 thin radial riblets with fine intermediate striae near the anterior border.

Measurements.—Pedicle valve (Cotype): Length, 3.5 mm.; width, 5.25 mm. Another example (Paratype): Length, 4.5 mm.; width, 8 mm. Brachial valve (Cotype): Length, 3.25 mm.; width, 5.5 mm.

Observations.—This neat little species belongs to the section of the genus styled Plicosae, having not more than 30 riblets. It agrees to some extent with the Wenlock species, *Chonetes minima*, Sowerby sp.,[1] but differs to a marked extent in the median division of the umbonal ridge, and by having a generally wider or more transverse shell. The "*Leptaena*" *minima* referred to by Prof. McCoy on quarter sheet No. 4 S.W. locality Bb 20, Kilmore Creek, probably related to this or an allied species.

Occurrence.—Silurian (Yeringian). Common in the mudstone of Ruddock's Quarry, near Lilydale; and at the Geol. Surv. locality Bb 16, at Simmonds' Bridge Hut on the Yarra.

Fam. PENTAMERIDAE.

Genus Conchidium, Linné.

Conchidium knightii, J. de C. Sowerby, sp. Plate XI., fig. 11.

Pentamerus knightii, Sowerby, 1813, Min. Conch., vol. i., p. 73, pl. xxviii. Idem, 1839, in Murchison's Silurian System, p. 615, pl. vi., figs. 8*a-c*. Davidson, 1867, Mon. Sil. Brach. (Pal. Soc.), vol. xx., p. 142, pl. xvi., figs. 1-3; pl. xvii., figs. 1-10; pl. xix., fig. 3. Etheridge, R., jnr., 1892, Rec. Geol. Surv., N.S.Wales. vol. iii., pt. 2, p. 54, pl. x., figs. 1-6; pl. xi., figs. 1-4.

Observations.—This fossil is not uncommon in the Silurian sandstones of Heathcote, Victoria. The examples are mostly in the condition of internal casts of the shell, but where the outer shell ornament is preserved the characteristic costation is seen.

Mr. Etheridge records this species from various localities in New South Wales, in strata of Silurian age, which he calls the "Pentamerus Limestones," and remarks on the fact of its being a characteristic fossil of the Aymestry Limestone in Wales and the West of England, occurring sparingly in the underlying Wenlock and the overlying Upper Ludlow.

1 *Leptaena minima*, Sowerby, in Murchison's Silurian System, 1839, pl. xiii., figs. 4, 4a.

Its occurrence in Victoria is interesting, as it seems confined to the Melbournian stage of the Silurian rocks.

Occurrence.—Silurian (Melbournian). Heathcote. From the Geol. Surv. Coll. Bb 50 " Ranges E. of Heathcote," and Bb 51 " Mt. Ida, N. of Heathcote."

Genus Clorinda, Barrande.

Clorinda linguifera, Sow. sp., var. *wilkinsoni*, Eth. fil.

Pentamerus linguifer, J. de C. Sowerby, Etheridge, R., jnr., 1892, Records Geol. Surv., N. S. Wales, vol. iii., pt. 2, p. 52, pl. xi., figs. 5-9.

Observations.—Two specimens, rather crushed, but still showing the characters of the above variety, were collected by the early Geological Survey of Victoria from " sect. xii. Parish of Yering," a locality west of the present Yering railway station. The specimens were tableted and labelled " *Pentamerus* " by Sir F. McCoy.

The variety *wilkinsoni* differs from the specific form, according to Mr. Etheridge,[1] " in its peculiarly flattened ventral sulcus, and other minor characters. As before said, it seems to occupy an intermediate position between *P. linguifer* and *P. globosus*."

Both Victorian specimens are ventral valves, and, although deformed by pressure, the anterior margin is sufficiently distinct to show the broad ventral sulcus mentioned by Etheridge as a character of his N. S. Wales variety. This variety occurs in N. S. Wales in the Bowning Series (the Lower Limestones and the Lower Trilobite Bed), and in the Silurian of Hatton's Corner, Yass.

Occurrence.—Silurian (Yeringian). Geol. Surv. Coll. Sect. xii., Parish of Yering (W. of Yering railway station).

Genus Gypidula, J. Hall.

Gypidula victoriae, sp. nov. Plate XI., fig. 12.

Description.—Shell sub-pentagonal or broadly ovate. Ventral valve very tumid, with the beak strongly incurved; mesial fold broad, elevated, commencing about one-third from the beak and extending to the anterior margin, and medially sulcated. Brachial valve almost flat or gently convex in the median area, curving backwards towards the anterior margin; with a broad mesial sinus bearing a distinct median plait extending from the hinge to the anterior margin. Numerous concentric growth-lines on both valves.

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1 Loc. cit., p. 33.

Cardinal aspect of shell similar to Davidson's figure 21*a*, of *Gypidula* ("*Pentamerus*") *galeata*, Dalman sp.,[1] but more strongly, although simply, plicate.

Measurements.—Length of shell (beak to anterior), 19 mm.; width, 21.5 mm. Greatest depth of brachial valve, 5.25 mm.; ditto of ventral valve, 12 mm.

Observations.—The above species is represented by a perfectly preserved cast of the shell, which, as it still retains the minute characters of the growth-lines, must be regarded as superficially replacing part of the shell itself.

Gypidula victoriae is closely related to *G. galeata*, Dalman sp.,[2] a characteristic Silurian fossil having an extensive vertical range. The latter is found in the Wenlock and Ludlow in England; the Gotlandian in Scandinavia; the newer Silurian in Bohemia; lower Helderberg in the United States; the Devonian of the Ural Mountains; and in the Middle Devonian of the Eifel, Germany.

The chief differences between the Australian and the other widely distributed species are, the greater gibbosity of the umbo of the ventral valve; the comparative flatness of the brachial valve; and the vellicate or pinched-up character of the plications, with a correspondingly strong flexure of the sinus and fold of the median area. That this Australian species is clearly referable to *Gypidula*, J. Hall, and not to *Sieberella*, Oehlert, is shown by the discrete character of the septum in the brachial valve seen in the present specimen.

Occurrence.—Silurian (Yeringian). In mudstone, near Lilydale (Ruddock's Quarry). Collected and presented by W. J. Parr, Esq.

Fam. ATRYPIDAE.

Genus Atrypa, Dalman.

Atrypa reticularis, Linné sp., var. *decurrens*, var. nov.

Plate XI., fig. 13.

Description.—Shell sub-circular to long ovoid; ventral valve depressed, brachial valve tumid in the median area, but not so ridge-like as in typical examples of *A. imbricata*. Ornament consisting of radiating riblets crossed by conspicuous concentric lamellar folds.

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1 Mon. Sil. Brach. (Pal. Soc.), pt. vii., No. 2., 1867, pl. xv., fig. 21*a*

2 *Atrypa galeata*, Dalman, Kongl. Vetensk. Acad. Handlingar, 1827, p. 130. *Pentamerus galeatus*, Dalman sp., Davidson, Mon. Sil. Brach. (Pal. Soc.), pt. vii., No. 2, 1867, p. 145, pl. xv. figs. 13-23.

Observations.—The Victorian specimens here ascribed to a new variety[1] are midway between *A. reticularis*, L. sp., and *A. imbricata*, Sow. sp.[2]. Although possessing the strong imbricating lamellae of *A. imbricata*, the well-marked fold and sinus so characteristic of Sowerby's species is in most of the Victorian examples nearly absent. In a few specimens the latter feature is conspicuous and more pronounced than in the type form *A. reticularis*, in which the median area is broadly rounded and widely concave respectively. The relationship of the variety *decurrens* to *A. reticularis* is seen in the more acute and well-pronounced riblets and elongate form as compared with *A. imbricata*.

Occurrence.—Silurian (Yeringian). In mudstone; Loyola, near Mansfield. Collected and presented by G. Sweet, Esq., F.G.S. Also at Yering, Upper Yarra, Victoria. Geol. Surv. Coll.

Atrypa aspera, Schlotheim sp. Plate XI., Fig. 14.

Terebratula aspera, Schlotheim, 1813, Leonhard's Taschenbuch, p. 74, pl. i., fig. 7; and Petrefactenkunde, 1820, pt. i., p. 263; pt. ii., 1822, p. 68, pl. xviii., fig. 3. *Atrypa aspera*, Schloth, sp., Dalman, 1827, Uppställring och Beskrifning af de i Sverige funne Terebratuliter; Kongl. Vetenskaps Acadamiens Handlingar für an 1827, p. 128, pl. iv., fig. 3. *Atrypa reticularis*, L. sp., var. *aspera*, Schloth., Davidson, 1865, Mon. Dev. Brach (Pal. Soc.), pt. ii., p. 57, pl. x., figs. 5-8.

Observations.—In common with other components of the rich Yeringian fauna of Victoria, this species is typical of the Devonian elsewhere, both in N. America and in England, and on the Continent. In N. America *A. aspera* var. *occidentalis*, Hall, occurs in the Middle Devonian (Hamilton Shales); whilst the typical species is found associated with *Atrypa reticularis* in the Middle Devonian Limestone of Devon and Cornwall. A curious lithological factor in regard to the distribution of this and the related form, *A. reticularis*, may here be noted, namely, the prevalence of *A. aspera* in the mudstones and of *A. reticularis* in the limestones, of the Yeringian stage; although both forms are occasionally found irrespectively of lithological conditions. This species has already been noted from both the Silurian and Devonian of Victoria by McCoy, who regarded it as a variety of *A. reticularis*.[3]

1 The name *decurrens* denotes a declension towards *A. imbricata*.

2 *Terebratula imbricata*, Sowerby, 1839, in Murchison's Silurian System, pl. xiii., fig. 27. *Atrypa imbricata*, Sowerby sp., Davidson, Mon. Sil. Brach. (Pal. Soc.), pt. vii., No. 2, 1867, p. 135, pl. xv., figs. 3-8.

3 Prod. Pal. Victoria, dec. v., 1877, p. 26.

Occurrence.—Silurian (Yeringian). In mudstone at Loyola, near Mansfield; collected and presented by Mr. G. Sweet, F.G.S. *Atrypa aspera* also occurs in the Middle Devonian limestone of Bindi, Gippsland, Victoria, specimens of which, in the National Museum collection, were collected many years ago by Dr. A. W. Howitt.

Atrypa fimbriata sp. nov. Plate XI., Fig. 15.

Description.—Shell, suborbicular, inflated. Brachial valve highly convex in the median and cardinal regions, suddenly descending to a concave and outspread anterior margin, the edge of which is ornamented with numerous outspread and irregularly disposed spines. Surface of value with 4 or 5 strong, sharp, concentric ridges, crossed by radial ribs, and forming nearly rectangular interspaces which are conspicuously excavated. The marginal spines, which are continuous with the radial ribs, are of variable length and variously directed, this latter feature probably owing to pressure. The type specimen is a well-preserved cast in which the shell seems to have been replaced by iron oxide.

Measurements (Holotype).—Length of shell to bases of spines, 16 mm.; width, 18 mm. Length of longest spine about 7 mm.

Observations.—This handsome species bears some relationship to two other forms of *Atrypa*, viz., *A. hystrix*, J, Hall,[1] and *A. spinosa*, J. Hall.[2] In *A. hystrix* the ribs are folded into tubular spines, mostly disposed round the margin of the shell, as in the present species; but the radials are not sharply defined, leaving concave areas in the interspaces between the concentrics and radials. On the other hand, in *A. spinosa* the shell is beset all over with spines, covering two-thirds of the total shell growth. Both *A. hystrix* and *A. spinosa* occur in much higher horizons than the present species; the former being found in the Chemung Group (Upper Devonian), the second in the Hamilton Group (Middle Devonian), of N. America.

Occurrence.—Silurian (Yeringian). In mudstone; near Lilydale. Specimen collected and presented by R. H. Annear, Esq.

Fam. SPIRIFERIDAE.

Genus **Cyrtina**, Davidson.

Cyrtina sub-biplicata, sp. nov. Plate XI., figs. 16*a-c*.

Description.—Shell small, sub-triangular. Pedicle valve with a high, triangular and arched cardinal area; remnants of the deltidial

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1 See Hall and Clarke, Pal. N. York, vol. viii., Brachiopoda, pt. ii., 1894, pl. lv., fig. 23.

2 See Iidem, ibid., pl. lv., figs. 21, 22.

plates or dental lamellae are seen attached to the sides of the cardinal area of the shell. A narrow slit-like depression, at the base of which the foramen was situated, is seen in the upper third of the deltidial area. Area on either side of the delthyrium transversely striate. Anterior margin of the pedicle valve irregularly flexuose. Cardinal extremities of valve blunt. Shell smooth, excepting for a few concentric, lamellar folds and the sharply plicate margins of the sinus, the latter being deeply sulcate.

Measurements.—Holotype: Length, 6 mm.; width, 9.75 mm.; length of hinge area, 3.5 mm.

Observations.—The nearest related form to the above is James Hall's *C. biplicata*,[1] a Lower Devonian species, which occurs in the Corniferous Limestone (Upper Helderberg) of Michigan, and in the Schoharie Grit of Schoharie, N. York (base of Upper Helderberg Group).

The present species differs in its blunt cardinal extremities and more deeply sunken sinus of the pedicle valve.

Occurrence.—Silurian (Yeringian). In brown mudstone at Ruddock's Quarry, near Lilydale. Collected and presented by J. S. Green, Esq.

Genus **Spirifer**, Sowerby.

Spirifer lilydalensis, sp. nov. Plate XI., figs. 17, 18.

Description.—Shell referable to the *S. sub-orbicularis* type; that is, "with sub-orbicular outline, broad, low and usually lateral plications; the median plications are few and indistinct."[2] Shell almost equally convex, with rounded to salient cardinal extremities. The pedicle valve is strongly curved towards the prominent beak; mesial sinus deeply excavate and feebly plicated, especially near the anterior margin, the margins of the sinus more or less ridge-like. The brachial valve bears a broad mesial fold, which is conspicuously, longitudinally striated. The general shell-surface is finely striated by delicate radial lines, and the shell is irregularly set off concentrically by a few lamellar growth-lines. Radial ribs rounded and gently curved; they number from 8 to 10 on each side of the fold and sinus.

Measurements.—A brachial valve (cotype): Length (anterior margin to beak), 19.5 mm.; width, 30.5 mm. A ventral valve (cotype): Length, 14 mm.; width, 22 mm.

1 See Hall and Clark, Pal. N. York, vol. viii., Pal. Brach., pt. ii., 1894, pl. xxviii., figs. 7-9.
2 Hall and Clarke, Pal. N. York, vol. viii., Pal. Brach., pt. ii., 1894, p. 26.

Observations.—This spirifer has marked characters of its own which make it easily separable from the other Victorian Silurian spirifers, namely, *S. plicatellus*, L. sp., var. *macropleura*, Conrad; *S. sulcatus*, Hisinger, sp.; and *S. perlamellosus*, J. Hall, var. *densilineata*, Chapm. The nearest related form to the present species is *S. concinnus*, J. Hall,[1] a spirifer of the sub-orbicularis type from the Lower Helderbergian of N. America. From *S. concinnus* the Lilydale species is separated by the smaller number of ribs, which vary from 8 to 10, against 12 to 14 in the Lower Helderberg form.

The Bohemian Silurian species, *Spirifer viator*, Barrande,[2] approaches our form in the young stage, but in the ephebic and gerontic conditions it has a remarkably large and salient mesial fold. Moreover there are fewer ribs in that species; that is, 6 to 7 on each side of the mesial fold and sinus.

Another somewhat related species is McCoy's *Spirifer bijugosus*, which occurs in the Wenlock Shale of Ireland.[3] So close is its resemblance to the Victorian fossils in many points that the writer had previously tentatively referred the latter to McCoy's species. In the number of the ribs the Irish species more nearly agrees with ours, being 10 to 12 on each side as compared with the Victorian with 8 to 10. The deep dividing groove of the mesial fold in *S. bijugosus* is sufficient distinction, however, to specifically separate our Victorian specimens. At the same time it is extremely interesting to note the double relationship of the two widely separated brachiopod faunas of the British Wenlockian Series and the Lower Helderbergian of N. America, with the Victorian Yeringian strata.

At a casual glance, Mr. W. S. Dun's Devonian species *S. pittmani*,[4] from N. S. Wales, might easily be mistaken for *S. lilydalensis*. The two forms belong, however, to separate groups. The ostiolate group to which *S. pittmani* and *S. yassensis* must be referred, have a smooth sinus and fold; while *S. lilydalensis* and the other related forms of the sub-orbiculate group have the median area striated or plicated.

Occurrence.—Well-preserved casts and moulds are often found in the brown mudstone of the Lilydale district. The cotype of the brachial valve was collected and presented by R. H. Annear, Esq.,

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1 Pal. N. York, vol. iii., 1859, p. 200, pl. xxv.; figs. 2a-i, and pl. xxviii., fig. 7. See also Hall and Clarke, ibid, vol. viii., pt. ii., 1894, pl. xxx., figs. 1, 2.

2 Système Silurien du centre de la Bohême, vol. v., 1879, pl. vii., figs. 4-11; pl. lxxiii., figs. iii., 1-8; pl. xxiv., fig. vi.

3 Synopsis Silurian Fossils Ireland, 1846, p. 36, pl. iii., fig. 23. See also Davidson, Brit. Sil. Brach. (Pal. Soc.), pt. vii., No. 1. 1866, pl. x., figs. 1-3, and pt. vii., No. 2, 1867, p. 89.

4 Dun, W. S. Rec. Geol. Surv. N. S. Wales, vol. vi., pt. 4, 1904, p. 320, pl. lxi., figs. 4, 4a, 4b

who obtained it from Wilson's Quarry, near Lilydale. An extensive series of the same fossil was collected and presented by the Rev. A. W. Cresswell, M.A., who obtained these spirifers from various exposures to the north of Lilydale. Silurian (Yeringian).

EXPLANATION OF PLATES.

Plate X.

Fig. 1.—*Siphonotreta plicatella*, sp. nov.: *a*, pedicle valve (holotype), × 6; *b*, profile of valve, × 6; *c*, ornament of anterior part of valve, × 18. Silurian (Melbournian): Yan Yean, Victoria. Coll. Mr. A. J. Shearsby, F.R.M.S.

Fig. 2.—*Crania pulchelloides*, sp. nov. *a*, apical aspect; *b*, profile. Silurian (Yeringian): Ruddock's Quarry, near Lilydale, Victoria. Coll. by Mr. W. J. Parr. × 4.

Fig. 3.—*Leptaena rhomboidalis*, Wilckens sp. Cardinal area and posterior portion of shell, to show denticulated hingeline. Silurian (Yeringian): Loyola, near Mansfield, Victoria. Coll. by Mr. G. Sweet, F.G.S. × 2.

Fig. 4.—*L. rhomboidalis*, Wilckens sp. Interior of a brachial or dorsal valve in the neanic stage, showing impression of the fleshy spiralia and crura. Silurian (Yeringian): Loyola, near Mansfield, Victoria. Coll. by Mr. G. Sweet, F.G.S. × 3.

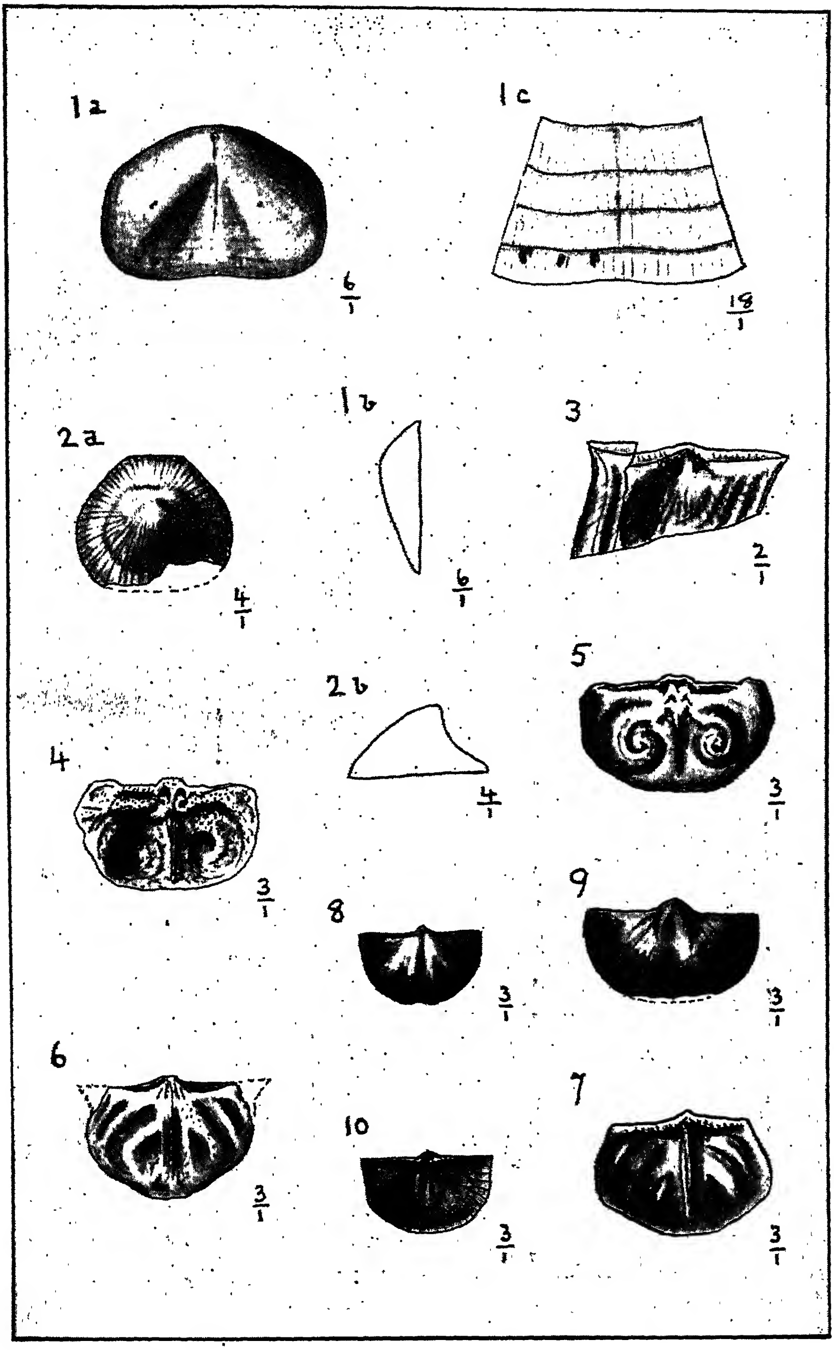
Fig. 5.—*L. rhomboidalis*, Wilckens sp. Wax squeeze from interior of brachial valve (Fig. 4), showing form of spiralia. × 3.

Fig. 6.—*L. rhomboidalis*, Wilckens sp. Natural cast in mudstone of interior of brachial valve. Silurian (Yeringian): Loyola, near Mansfield. Coll. by Mr. G. Sweet, F.G.S. × 3.

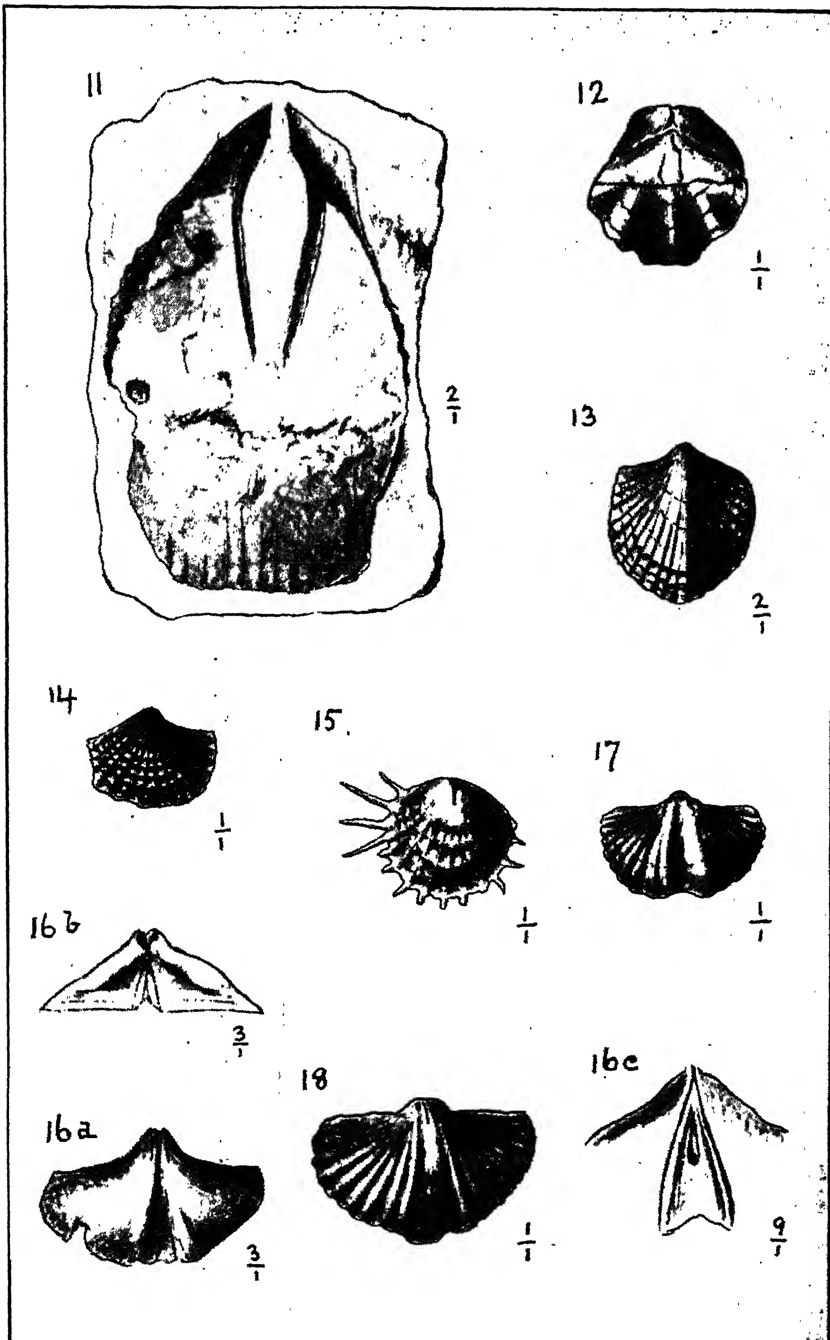
Fig. 7.—*L. rhomboidalis*, Wilckens sp. Wax squeeze from natural impression of brachial valve (Fig. 6), showing brachial impressions. × 3.

Fig. 8.—*Chonetes bipartita*, sp. nov. Pedicle valve (cotype). Silurian (Yeringian): Ruddock's Quarry, near Lilydale. Coll. by Mr. J. S. Green. × 3.

Fig. 9.—*C. bipartita*, sp. nov. Pedicle valve of a larger example (paratype). Silurian (Yeringian): Simmonds' Bridge Hut on the Yarra. Coll. Geol. Surv. Vict. × 3.



F. C. ad. nat. del.



F. C. ad. nat. del.

Fig. 10.—*C. bipartita*, sp. nov. Brachial valve (cotype). Silurian (Yeringian): Simmonds' Bridge Hut on the Yarra. Coll. Geol. Surv. Vict., × 3.

PLATE XI.

Fig. 11.—*Conchidium knightii*, J. de C. Sowerby, sp. Cast and mould of shell in fine sandstone; showing the spondylium and general form and ornament of the shell. Silurian (Melbournian): Heathcote, Victoria. Coll. Geol. Surv. Vict. × 2.

Fig. 12.—*Gypidula victoriae*, sp. nov. Brachial aspect of shell. Silurian (Yeringian): Ruddock's Quarry, near Lilydale. Coll. by Mr. W. J. Parr. Natural size.

Fig. 13.—*Atrypa reticularis*, Linné, sp. var. *decurrens*, var. nov. A wax squeeze taken from a mould in mudstone, of a ventral valve. Silurian (Yeringian): Ruddock's Quarry, near Lilydale. Coll. by Mr. W. J. Parr. × 2.

Fig. 14.—*A. aspera*, Schlotheim, sp. A wax squeeze taken from a natural mould in mudstone, of a ventral valve. Silurian (Yeringian): Loyola, near Mansfield. Coll. by Mr. G. Sweet, F.G.S. Nat. size.

Fig. 15.—*A. fimbriata*, sp. nov. A brachial valve (holótype). Silurian (Yeringian): near Lilydale. Coll. by Mr. R. H. Annear. Nat. size.

Fig. 16.—*Cyrtina sub-biplicata*, sp. nov.: *a*, pedicle valve, × 3; *b*, area of pedicle valve, showing the cardinal area with pseudodeltidium, × 3; *c*, pseudodeltidum under higher magnification, showing the form and position of the pedicle foramen, × 9. Silurian (Yeringian): Ruddock's Quarry, near Lilydale. Coll. by Mr. J. S. Green.

Fig. 17.—*Spirifer lilydalensis*, sp. nov. Pedicle valve (cotype). Silurian (Yeringian): north of Lilydale. Coll. by the Rev. A. W. Cresswell, M.A. Nat. size.

Fig. 18.—*S. lilydalensis*, sp. nov. Brachial valve of a larger example (cotype). Silurian (Yeringian): Wilson's Quarry, near Lilydale. Coll. by Mr. R. H. Annear. Nat. size.

CORRIGENDUM.

In Part XV. of this series, vol. XXV., part I., 1912, p. 192, line 8 from top, after Fig. 7.—read "*Pleurotoma sayceana.*"

[Proc. Roy. Soc. Victoria, 26 (N.S.). Pt. I., 1913.]

Art. X.—*Further Notes on Australian Hydroids.—II.*

By W. M. BALE, F.R.M.S.

(With Plates XII., XIII.)

[Read 10th July, 1913.]

The present paper is in continuation of my last communication to the Society, which was read in April, 1893. During the somewhat long interval but little has been done in Australia towards advancing our knowledge of its hydroid fauna, the only contributions which I am aware of being those of Messrs. Bartlett, Mulder, and Trebilcock, in the "Geelong Naturalist." A number of new and interesting forms were made known in these papers, mostly among the smaller species, and principally from collections made in or near Port Phillip; and since this is the case with a locality which has perhaps been better searched than any other in the States, it may readily be imagined what a wealth of information remains to be gathered by future investigators along our less-explored shores.

A quantity of hydroid material which was dredged by the "Thetis" in 1898 was sent to Mr. Jas. Ritchie, of the Royal Scottish Museum, Edinburgh, and the results were published by the Australian Museum in one of its Memoirs nearly two years since. In this paper a number of new forms are described, and a good deal is added to our knowledge of already-known species.

A number of hydroids dredged from time to time by the Commonwealth trawler "Endeavour" have been placed in my hands for examination, among them being some new and striking forms obtained from the little-explored region of the Great Australian Bight. These form the subject of a Report, which was completed some months since, and which it is expected will shortly be published. A small lot of material since received contains several additional forms new to our fauna, which I hope to report upon at a future date.

Though no other works have appeared specially devoted to the Australian Hydroida, many of our species have been described in accounts of collections made in other parts of the world during recent years, and the number of forms known to be common to Australia and other regions has been considerably augmented, while numerous changes in nomenclature have found more or less accept-

ance. Many specific names formerly adopted by me have been ranked as synonyms of older species, following on the examination of museum types of former observers, whose descriptions were so incorrect or inadequate that it had been impossible to identify the species which they were intended to indicate. This is especially the case with the hydroids described by Lamarck and Lamouroux, of whose descriptions a great many were quite valueless, so that the species remained unidentified for nearly a century, till Dr. Billard recorded the results of his examination of the type specimens. The same observer has also examined the British Museum collections, and finds a number of the species (Australian and other) described by Allman in the "Challenger" Report, and elsewhere, to be identical with previously-known forms (in addition to those which I had, in former papers, noted as synonyms of some of Busk's and Kirchenpauer's species). I may remark in passing that a similar revision of Kirchenpauer's types would be very serviceable. His accounts of some of the species leave much to be desired, and in two or three cases where the types have been examined, they prove to be such as could not be recognised from the descriptions and figures.

A few of the species dealt with in the following pages have been treated by recent observers as synonyms of older species, from which they are really distinct, and to clear up their affinities I have described them more fully, though in fact, some of the original descriptions were inconsistent with the synonymy assigned to them. Two of Busk's species, which have only been identified in recent years, are here fully described, and one or two changes are made in specific names, for various reasons. In view of the unfortunate vehicle of publication chosen by the Geelong observers (the "Geelong Naturalist" being issued in such limited numbers that scarcely any copies were available for purchase), I proposed re-describing such of the new species, as I had, through the courtesy of Mr. Mulder, obtained specimens of, but have had to postpone doing so to a possible future opportunity.

I cannot let pass this occasion (the first which has presented itself) of expressing my hearty thanks to those observers who have favoured me with their publications. These are:—Miss Laura Thornely, of Liverpool; Dr. R. Kirkpatrick, of the British Museum; Mr. Jas. Ritchie, of Edinburgh; Dr. E. T. Browne, of Berkhampstead; Dr. A. Billard, of Paris; Professor M. Bedot, of Geneva; Professor G. M. R. Levinsen and Mr. P. Kramp, of Copenhagen; Dr. Cl. Hartlaub, of Heligoland; Dr. Elof Jäderholm, of Sweden; Dr. E. Stechow, of Munich; A. K. Linko, of St. Petersburg; Dr. G. Mark-

tanner-Turneretscher, of Graz, Austria; Professor C. C. Nutting, of Iowa City; Dr. C. McLean Fraser, of British Columbia; Professor S. F. Clarke, of Williamstown, Massachusetts; Dr. A. G. Mayer, of Cambridge, Massachusetts; Dr. E. Warren, of Natal; Mr. Inaba, of Kyoto; Mr. H. Farquhar, of Wellington; Mr. Thos. Whitelegge, of Sydney; Mr. J. F. Mulder, of Geelong; Professor R. von Lendenfeld.

I have also to gratefully acknowledge the assistance rendered to me in other ways, especially by Professor Nutting, Dr. Stechow, Dr. Hartlaub, Dr. Kirkpatrick, Mr. Ritchie, Dr. Billard and Mr. Mulder, who have either sent me specimens, or compared my specimens with types, or otherwise assisted me in the endeavour to settle the affinities of doubtful forms.

Hydra viridis Linné.

Hydra viridis, Linné, Faun. Suec., 1746, p. 367; id., Syst. Nat. I., 1767, p. 1320; Johnston, Brit. Zooph., 1847, p. 121, fig. 28; Hincks, Brit. Hydr. Zooph., 1868, p. 312, fig. 40; Bedot, Zool. Anzeig, xxxix., 1912, p. 603.

Hydra viridissima, Pallas, Elenchus, 1766, p. 31; Brauer, Zool. Anzeig, xxxiii., 1908, p. 790.

H. viridis has not hitherto been included in lists of the Australian hydroids, but it is found abundantly, in company with the brown hydra, in ponds bordering the Yarra near Melbourne; and its occurrence in those localities has been noticed in the "Victorian Naturalist" on several occasions.

Pennaria wilsoni, n. nom.

Halocordyle australis, Bale, Proc. Roy. Soc. Victoria, N.S., vi., 1893, p. 94.

It is now generally recognised that the genus *Halocordyle* is not really distinct from *Pennaria*, to which genus our *H. australis* must accordingly be relegated. In order to avoid confusion with *P. australis* Bale (although that species is now considered by some observers to be only a variety of *P. cavolinii*), it seems advisable to re-name the present form, which was dredged in Port Phillip by the late Mr. J. Bracebridge Wilson.

All the species hitherto referred to *Pennaria* appear to be identical in habit, the stem giving off two series of alternate branches, which are both in the same plane, or nearly so, while the short polypiferous ramuli form a single series along the distal side of the branches. In *P. wilsoni* (at least in the mounted specimens), the

branches are all directed to one side, and so appear at first sight to be uniserial; in reality, however, they originate in two planes about 90 deg. apart, but are then directed so decidedly forward that when mounted they fall to the same side, and seem to have a secund disposition. A more important distinction, however, is the arrangement of the ultimate ramules, which in *P. wilsoni* are biserial, and like the branches are in two planes about 90 deg. from each other. They are, as a rule, alternate, but there are sometimes irregularities in their disposition, such as two occurring in succession on the same side. This arrangement, and the very much more pronounced annulation, distinguish the polypidom from that of *P. australis*.

The only specimens I have seen consisted of two mounted pieces, and Mr. Wilson was unable to say what the size of the original specimen had been, or to give any further details of the ramification.

HEBELLA SCANDENS (Bale.) (Plate XII., Fig. 10).

Lafoëa scandens, Bale, Proc. Lin. Soc. N.S.W., 2nd Ser., iii., 1888, p. 758, pl. xiii., figs. 16-19.

Hebella scandens, Marktanner-Turneretscher, Ann. d. k. k. Naturh. Hofmus., v., 1890, p. 214, pl. iii., fig. 16; Farquhar, Trans. N.Z. Inst., xxviii.. 1896, p. 460; Campenhausen, Zool. Inst. d. Univ. Jena, 1897, p. 307 (?); Hartlaub, Zool. Jahrb., Suppl. vi., iii., 1905, p. 587; Warren, Ann. Nat. Gov't. Mus., i.. 1908, p. 341, fig. 21; Levinsen, Vidensk. Medd. f. d. naturh. Foren, 64, 1913, p. 285.

Lictorella scandens, Borradaile, Fauna and Geogr. of the Mald. and Laccad. Archipel. ii., 1905, p. 840.

Hebella cylindrica (in part), Pictet, Rev. suisse de Zool., i., 1893, p. 41, pl. ii., fig. 36; Versluys, Mém. de la Soc. Zool. de France. xii., 1899, p. 31.

Lafoëa calcarata (in part), Billard, Bull. du Mus. d'Hist. nat., 1904, p. 481; id., Exp. Sci. du Trav. et du Tális-man, viii., 1907, p. 174.

Hebella calcarata (in part), Billard, Arch. de Zool. Exp. et Gén., 4 sér., vii., 1907, p. 339; Ritchie, Proc. Zool. Soc. Lond., 1910, p. 810; id., Mem. Austr. Mus., iv., 1911, p. 816.

Hebella contorta, Marktanner-Turneretscher, Ann. d. k. k. naturh. Hofmus., v., 1890, p. 215, pl. iii., fig. 17 a, b; Campenhausen, Zool. Inst. d. Univ. Jena, 1897, p. 307; Levinsen, Vid. Medd. f. d. naturh. Foren, 64, 1913, p. 285, pl. v., figs. 16, 17.

(?) Not *Lafoëa calcarata*, Agassiz, Mem. Mus. Comp. Zool. Harvard, i. 1865, p. 122, fig. 190; Hargitt, N. Amer. Nat., xxxv., 1901, p. 387, fig. 24.

(?) Not *Hebella calcarata*, Nutting, Bull. U.S. Fish. Comm., xix., 1901, p. 353, 378, figs. 56, 94.

Not *Lafoëa cylindrica*, von Lendenfeld, Proc. Lin. Soc. N.S.W., ix., 1884, p. 912, pl. xl., figs. 4, 5.

This is one of a series of closely-allied forms, the specific relationship of which is more or less doubtful. Pictet first classed together the *Lafoëa cylindrica* of von Lendenfeld, *Hebella contorta* and *H. cylindrata* of Marktanner-Turneretscher, and—somewhat doubtfully—*Lafoëa scandens*. Billard added to the list *Lafoëa calcarata*, Agassiz, of which he regards all the others as synonyms.

Pictet claims that he finds in Amboyna specimens, in the same colony, hydrothecae coinciding exactly with the descriptions of the three species which he unites (other than *H. contorta*), and his only reason for doubt as to the identity of *H. scandens* arises from an apparent difference in the gonophores. Regarding *H. contorta* he remarks, referring to the flexure of the hydrothecae, "Nous ne pensons pas cependant qu'il y ait lieu d'en faire une espèce distincte, car ce n'est évidemment qu'un phénomène pathologique provenant, soit d'une mauvaise méthode de conservation, soit d'une autre cause inconnue." The assumption that the bent form of the hydrothecae is due to bad preservation is perfectly groundless; it is the usual and normal condition of this hydroid, which, however, does not seem to me to differ more than varietally from *H. scandens*, especially since Levinsen has shown that its gonangium is exactly similar to that of the latter species.

My experience differs from that of Pictet in regard to the trophosome. I have observed many colonies of *H. scandens*, and several of *H. contorta*, but have not found any great variation in the hydrothecae. And Pictet does not explain how he was able to satisfy himself that the characters of *L. cylindrica* are such as to justify its association with the other forms; Von Lendenfeld's statement that his species has the hydrothecae "large as in *L. parasitica*" seems to forbid such association, and there is reason to believe that it is identical with a form to be described further on, whose size is such as to take it far out of the range of the species or variety observed by Pictet.

The gonosome of Pictet's specimens is described thus:—"Gonothèques allongés, recourbés en forme de corne d'abondance, à parois lisses, renfermant trois bourgeons medusoïdes en forme de cloche,

disposés sur une rangée." According to the figure the aperture is circular and entire.

The gonangium of *H. scandens* and *H. contorta* is not recurved cornucopia-fashion, and its wall is not smooth, but feebly annulated; its aperture when mature is divided into several shallow emarginations, each with its opercular flap. As Levinsen justly remarks, "The gonothecae of *H. contorta* seem to be very different from those of *H. calcarata* and *H. cylindrica*, figured by Agassiz and Pictet."

As to the gonophores themselves, Pictet says, "Dans cette espèce [*H. scandens*] en effet, les gonothèques contiendraient deux gonophores renfermant chacun trois à quatre œufs et surmontés d'un gros blastostyle en forme de trompette, tandis que sur les exemplaires récoltés à Amboine, les gonothèques renferment trois bourgeons médusoïdes en forme de cloche très facilement reconnaissables."

He goes on to suggest that the apparent blastostyle of *H. scandens* is really the first medusoid bud, an erroneous interpretation having been given to badly-preserved specimens. The suggestion as to the blastostyle is somewhat extraordinary, as it is difficult to imagine how the structure which I have figured (as it exists) could be confused with a gonophore; nevertheless, I have no doubt that Pictet is correct in supposing that the gonophores are medusoid, and it is quite possible that three may be produced, though not all at one time, as in the form which Pictet has figured. In the few specimens which seemed to be complete there appeared first the large trumpet-shaped blastostyle, then the first gonophore, which; however, was not in a condition to enable its structure to be made out satisfactorily, and below this the second bud, an ovate body in a much more rudimentary stage of development. In one or two instances there was at the base of the gonotheca a slight enlargement, which may perhaps have been the earliest rudiment of a third medusoid, but its minute size and the presence in each case of foreign matter obscuring it made its character a matter of uncertainty. If a gonophore, its development must be very late, for even in a case where the first had escaped, and the second seemed mature, it was still apparently no further advanced.

On the whole I conclude that Pictet's own account of both the gonotheca and its contents, if correct, furnishes strong evidence against the identity of his specimens with *H. scandens*, and reasons will be given for believing *H. cylindrica* to be an entirely different species. I have not seen *H. cylindrata*, and therefore offer no opinion regarding it. As to *H. calcarata*, it may possibly be the

same as *H. scandens*, but the descriptions certainly do not establish their identity. A. Agassiz says that the gonangia are gigantic as compared with the hydrothecae, which is decidedly not the case with *H. scandens;* their form also is different. The more advanced medusa is said to fill the cavity of the gonangium almost entirely, and to be from 1-20th to 1-16th of an inch long when it escapes. In *H. scandens* the largest medusa measured in each case, when apparently about mature, slightly under 1-40th of an inch, and never occupied more than a small proportion of the gonangium. According to Agassiz, Nutting, and Hargitt the hydrothecae of *H. calcarata* are very strongly curved at the base (Nutting says doubly curved), and are generally borne in pairs, neither of which conditions obtain in *H. scandens*. The free medusa of *H. calcarata* is well known, but that of *H. scandens* has not been observed, nor has that of Pictet's specimens.

Hebella cylindrica (Von Lendenfeld). (Plate XII., Fig. 11.)

Lafoëa cylindrica, Von Lendenfeld, Proc. Lin. Soc. N.S.W. ix., 1884, p. 912, pl. xl., figs. 4, 5.

Not Hebella cylindrica, Pictet, Rev. Suisse de Zool., i., 1893, p. 41, pl. ii., fig. 36; Versluys, Mém. Soc. Zool. de France, xii., 1899, p. 31; Weltner, Hydr. von Amboina u. Thursday Id., 1900, p. 586; Jäderholm, Arkiv. f. Zool., k. svenska Vetenskapsakad, i., 1903, p. 274.

All the records of *H. cylindrica* since the date of Pictet's paper on the Hydroids of the Bay of Amboina, refer to small forms like *H. scandens*, which were, by that author, associated under the name of *H. cylindrica*. The form which I now, with little hesitation, refer to that species is of far larger size than any of these, but it certainly agrees better with Von Lendenfeld's figure and description, neither of which, however, directly indicates the size of the specimens. The drawing is said to be made with "A objective and C ocular," without even intimating whose lenses are referred to; if Zeiss', the combination quoted would give a magnification of over 100, and the figure, if on that scale, would represent a form with the hydrothecae less than .25 mm. in length, or much too small for even *H. scandens*. As Von. Lendenfeld expressly mentions that the hydrothecae, as well as the hydranths, are "large as in *L. parasitica*," it is evident that the reference to the lenses employed does not indicate the scale on which the figure was drawn.

The specimen now in question has hydrothecae about 1 mm. in length, or slightly larger than those of *H. parasitica*, and more than double the average of *H. scandens*, and stout in proportion. It agrees perfectly with Von Lendenfeld's figure, except that the rim of the hydrotheca is a trifle less everted. This rim is doubled in one case, but the two rims are extremely close together. It is growing on *Synthecium alternans*, as shown in the figure, and for comparison I give a figure on the same scale of *S. cylindricum* with *H. scandens* growing on it. The hydrothecae of the two species of *Synthecium* are of about the same size, and it will be seen that the comparatively gigantic hydrothecae of *H. cylindrica* surpass in size those of the *Synthecium* as much as the latter exceed those of *H. scandens*.

The specimen of *S. alternans* on which this *Hebella* was found was a small piece (apparently a pinna) sent to me by Dr. Kirkpatrick from the "Challenger" collection. I at first contemplated describing the *Hebella* as new, but on comparing it with Von Lendenfeld's account of *H. cylindrica*, found it so closely similar as to suggest the strong probability of their being the same. This conclusion is arrived at from the figure of the supporting hydroid, as well as from that of the *Hebella* itself. Von Lendenfeld says that the species grows on Sertularians, but mentions no particular species. The figure agrees, however, very fairly with *Synthecium alternans*, and not with any other Sertularian which I am acquainted with; moreover, the relative sizes of the Sertularian and the *Hebella* are much the same as those of *S. alternans* and the species under consideration; there is every probability therefore that these two are the same forms that Von Lendenfeld has figured.

The species differs from *H. scandens* (at least so far as this specimen is concerned), in the absence of the chitinous "floor" of the hydrotheca. There is an unmistakable "floor," on which the flattened base of the hydranth is supported, but it appears to be purely membranous, and not an ingrowth of the perisarc, as in *H. scandens*.

SERTULARIA LOCULOSA Bale. (Plate XII., Figs. 7, 8.)

Sertularia loculosa, Bale, Aust. Hydr. Zooph., 1884, p. 91 (part), pl. iv., figs. 5, 6, pl. xix., fig. 9; Warren, Ann. Natal Gov't. Mus., i., 1908, p. 306, fig. 8, pl. xlviii., fig. 37.

Sertularia turbinata, Billard, Ann. Sci. Nat., 9 sér., xi., 1910, p. 19 (in part); (?) Ritchie, Proc. Zool. Soc. Lond., 1910, p. 821.

Not *Sertularia loculosa*, Busk. Vide *Sertularia turbinata* (Lampuroux), p. 124.

Not *Dynamena turbinata*, Lamouroux, Vide p. 124.

Hydrocaulus about half an inch in height, often continued into a stolon, unbranched. Hydrothecal internodes mostly a little shorter than the width across the hydrothecae, one or two at the summit often much elongated, nodes sometimes single and transverse, often double, with the lower transverse and the upper conspicuously oblique and slender, the latter occurring at irregular intervals.

Hydrothecae opposite, a pair on each internode, divergent, but with the lower portions in contact or approximate in front, separated behind; mostly short and squat in form, with a distinct oblique fold or ridge crossing them about the middle; aperture looking outwards and upwards, with two lateral teeth, generally blunt and rounded, but in some specimens more pointed, a third tooth often developed above.

Gonothecae ovate, truncate, not compressed, with several strong annular ridges; summit with a wide operculate opening; borne on the lower part of the shoots.

Colour, brown, pale to very dark.

Hab.—Queenscliff; Port Phillip; Portland (Mr. Maplestone); Natal Coast, common (Warren).

Under the name of *S. loculosa* Busk, I included in the "Catalogue of the Australian Hydroid Zoophytes," along with Busk's type, two or three forms which I had observed in collections from Port Phillip. One of these, of pinnate habit, is probably identical with *S. inflata* (Versluys), and, with that species, is referred in the present paper to the *Dynamena marginata* of Kirchenpauer. The other varieties differ considerably from Busk's, and I have long been doubtful whether they should not be separated, though reluctant to propose a new name on grounds perhaps insufficient.

In 1909 Billard announced, as a result of his examination of Lamouroux' types, that the *D. turbinata* of that author is the same as Busk's *S. loculosa*, corresponding in all respects, as Dr. Billard informs me, with Busk's drawing. I now propose, while accepting the original name, *S. turbinata*, for Busk's species, to separate the common short-celled form, and to retain for it the name of *S. loculosa*, under which it is already generally known. The grounds of separation will be briefly stated.

In *S. loculosa*, as restricted, the hydrothecae are short and squat in form, slightly divergent throughout, so that the two constituting

a pair are in contact in front only at the lower part, and the bases of the hydrothecae, as well as the transverse ridges, run obliquely to the axis of the hydrocaulus. In *S. turbinata* the hydrothecae are more erect in the lower part, the main divergence being above the ridge, which is at right angles to the axis of the hydrocaulus. The vertical ridge where the two hydrothecae meet is not continued downward in *S. loculosa* as it often is in *S. turbinata*. The mouth in *S. loculosa* is upward-directed, with distinct lateral teeth, while in the other form it looks rather downward, and the lateral teeth or lobes are but feebly developed.

The internodes in *S. turbinata* are separated by simple nodes, transverse or very slightly oblique, which are usually very close above the hydrothecae. In *S. loculosa* similar nodes exist, but in addition to and above them there are found at irregular intervals oblique nodes, in which the base of the upper internode runs down into a point in front, while the top of the lower one is produced upward into a similar point at the back. Such double joints may occur between most of the hydrothecal internodes on a shoot, or there may be only one or two of them, and the straight ones vary a good deal in distinctness. The effect is that the short section of hydrocaulus between them constitutes a separate internode, as Warren justly describes it, and the condition is exactly similar to that of many species of *Plumularia*, in which the short intermediate internode is separated from the hydrothecal internode above by a long oblique joint, and from that below by a straight transverse one, often less distinct. The only difference is that in *Plumularia* the short intermediate internodes are of regular occurrence, while here they are irregular.

In both *S. loculosa* and *S. turbinata* one or two internodes—usually only one—at the summit of a shoot may be very much elongated below the hydrothecae, but the hydrothecae themselves are not longer than those found elsewhere. In some specimens of *S. loculosa* ("Catalogue," pl. iv., fig. 6) the hydrothecae are less squat than usual, with the teeth less obtuse, a variation which approximates them to *S. marginata*, but not to *S. turbinata*.

Warren finds *S. loculosa* common on the Natal coast, and his detailed description leaves no doubt of its identity with the common Australian form. Only in the gonangia is any difference indicated, the Natal form having from seven to nine annulations, while my specimens have only five. The difference may possibly be sexual; Warren's figured specimen was female, but he does not state whether the male was observed; my specimens were empty, and in only two of them have I seen the gonangia at all.

Billard has associated under the name of *S. turbinata* not only the two simple forms referred to above, but also the pinnate form described by Kirchenpauer as *Dynamena marginata*, and also known as *S. inflata* (Versluys), and by other names. This will be further referred to under *S. marginata*.

SERTULARIA TURBINATA (Lamouroux). (Plate XII., Fig. 6.)

Dynamena turbinata, Lamouroux, Hist. Polyp. Cor. Flex., 1816, p. 180; id., Encycl. Méth. ii., 1824, p. 290.

Sertularia turbinata, Lamarck, An. s. Vert., 2nd Ed. ii., 1836, p. 154; Bale, Aust. Hyd. Zooph., 1884, p. 96; Billard, C. R. Acad. d. Sci., cxlviii., 1909, p. 1064; id., Ann Sci. Nat. (9 ser.), ix., 1909, p. 322 (in part); Id. (9 sér.), xi., 1910, p. 19 (in part).

Sertularia loculosa, Busk, Voy. of Rattlesn. i., 1852, p. 393; Bale, Aust. Hydr. Zooph., 1884, p. 91 (part), pl. ix., fig. 12; Jäderholm, Ark. f. Zool., k. svenska Vetenskapsakad, i., 1903, p. 285.

Not *Sertularia loculosa* Bale. Vide p. 121.

Hydrocaulus about half an inch in height, often continued into a stolon, unbranched. Internodes mostly a little longer than the width across the hydrothecae, the proximal one shorter, one or two at the summit often much elongated; nodes transverse, mostly immediately above the hydrothecae.

Hydrothecae opposite, a pair on each internode, in contact in front for a considerable part of their length, separated behind; upper portion divergent almost horizontally, a distinct horizontal fold or ridge crossing them about the middle; the thickened vertical ridge marking their union in front often continued downward beyond the bases of the hydrothecae; aperture looking outwards and somewhat downwards, with two very indistinct lateral lobes.

Gonothecae not compressed, with five or six strong annular ridges, summit with a wide operculate opening; borne on the lower part of the shoots or on the hydrorhiza.

Colour, brown, often very dark.

Hab.—Bass Strait, 45 fathoms (Busk): Java Sea (Jäderholm): Paumben, India (?) (Jäderholm).

The characters which distinguish this—the original type of *S. loculosa*, Busk—from the short-celled form hitherto associated with it have been detailed under *S. loculosa*, and will be obvious on reference to the figures.

The precise form of the hydrotheca-margin is doubtful. In the best-preserved specimens there is an angle in the middle of the upper side, but no tooth, and the lower side is simply rounded, or with two lateral lobes scarcely indicated. But so delicate is the perisarc at the margin that the shape seems in all cases more or less altered. Even in the fresh specimens the condition seems to have been similar, as Busk described the aperture as irregular. In *S. loculosa* the perisarc is stouter, and there is even a distinctly thickened border to the aperture, but this is wanting in *S. turbinata*, at least in these specimens.

Whether the oblique nodes, which in *S. loculosa* are found in addition to the simple transverse ones, ever occur in *S. turbinata*, I cannot say. None exist in my specimens, which consisted altogether of about sixty internodes, and Jäderholm, whose specimens corresponded with Busk's figure, does not mention them.

The gonangia are similar to those of *S. loculosa*, with, according to Jäderholm, five or six annulations.

The species appears to be rare. I have seen no examples other than Busk's, though *S. loculosa* is quite common in the same locality (Bass Strait), and the only other record I have met with, besides Lamouroux', is that of Jäderholm. Possibly *S. loculosa* is a shallower-water form, and hence more often thrown on the beach.

In considering the validity of the distinction which I have drawn between these two forms it must be borne in mind that I have had only the one mounted colony of *S. turbinata* under examination. It remains for future investigation to determine the relationship between the two forms.

Sertularia marginata (Kirchenpauer). (Plate XII., Fig. 9.)

Dynamena marginata, Kirchenpauer, Verh. d. K. L.-C., deutschen Akad. d. Naturf., xxxi., 1864, p. 13, figs. 8-8c.

Sertularia flosculus, D'Arcy W. Thompson, Ann. and Mag. N.H., Ser. 5, iii., 1879, p. 104, pl. xvii., figs. 2-2a.

Sertularia amplectens, Allman, Journ. Lin. Soc., Zool., xix., 1885, p. 141, pl. xvi., figs. 3, 4; Jäderholm, Bihang till. k. svenska Vet.-Akad., xxi., 1896, p. 13, pl. i., fig. 9.

Desmoscyphus gracilis, Allman, Chall, Rept., Part ii., 1888, p. 71, pl. xxxiv., figs. 2-2c.

Desmoscyphus inflatus, Versluys, Mém. Soc. Zool. de France, xii., 1899, p. 42, figs. 11-13.

Desmoscyphus brevicyathus, Versluys, Mém. Soc. Zool. de France, xii., 1899, p. 40, figs. 9-10.

Sertularia inflata, Jäderholm, Ark. f. Zool. k. svenska Vetenskapsakad, i., 1903, p. 286; Vanhöffen, Deutsche Südp.-Exp., 1901-3 xi., 1910, p. 321, f. 38; Stechow, Zool Jahrb., xxxii., 1912, p. 361.

Sertularia versluysi, Nutting, Amer. Hydr.—Sert., 1904, p. 53, pl. i., f. 4-9; Billard, Actes., Soc. Lin. Bord., lxi., 1906, p. 74; id., C. R. Acad. d. Sci., cxlviii., 1909, p. 194; id., Bull. Mus. Hist. Nat., xiii., 1907, p. 275; Congdon, Proc. Amer. Acad. Arts and Sci., xlii., 1907, p. 481; Ritchie, Proc. Zool. Soc. Lond., 1907, p. 505, fig. 144, pl. xxiv., fig. 2-6; Fraser, Bull. Bureau of Fisheries, xxx., 1912, p. 375, fig. 40.

Sertularia brevicyathus, Nutting, Amer. Hydr.—Sert., 1904, p. 60, pl. vi., figs. 1-2.

Sertularia turbinata, Billard, An. Sci. Nat., 9 sér., xi., 1910, p. 19 (in part).

Not *Dynamena turbinata*, Lamouroux, Hist. Polyp. Cor. Flex., 1816, p. 180; id., Encyc. Méth., ii., 1824, p. 290.

Not *Sertularia turbinata*, Lamarck, An. s. Vert., 2nd Ed., ii., 1836, p. 154.

Hydrophyton monosiphonic, pinnate (rarely simple) often under half an inch in height, but sometimes reaching two inches. Proximal portion of the stem without pinnae or hydrothecae. Pinnae alternate, each borne on a distinct process at the base of a stem-internode, which supports also an unpaired hydrotheca in the axil, and a pair of sub-alternate hydrothecae above. First internode of each pinna short, without hydrothecae, separated from the next internode by an oblique conspicuous joint, at which it readily separates; joint between the first internode and the cladophore straight, often less distinct or obsolete; nodes slender and oblique, or straighter, and less distinct.

Hydrothecae of the pinnae or simple shoots in pairs, opposite, mostly in contact in front, short and stout, with a slight oblique fold or ridge crossing them about the middle; aperture nearly vertical, with two large pointed triangular lateral teeth, and sometimes with a third smaller tooth above.

Gonothecae oblong, compressed and lenticular in transverse section (flattened behind and convex in front), with several distinct transverse annulations; the superior angles produced upwards into two large incurved horn-like processes; aperture narrow.

Colourless or brownish.

Hab.—Williamstown, Port Phillip.

I have in the main followed Billard in the synonymy of this species, adding, however, *S. brevicyathus*, and excluding the two unbranched forms, *S. loculosa* and *S. turbinata*, already treated of. The two latter forms, besides being always, so far as is known, unbranched, differ from the present in the form of the gonangia, which are rounded in section, with a wide operculum covering the whole of the summit, while those of the pinnate form are plano-convex, with two incurved horns at the upper angles, and opening by a narrow slit. It happens that the only specimens hitherto recorded with the gonosome sufficiently preserved for the sex to be ascertained are those of *S. inflata*, observed by Ritchie, which bore male gonophores, and those of *S. loculosa*, seen by Warren, in which the gonophores were female. Billard thereupon suggests that this may be a case of sexual dimorphism, the pinnate form being habitually associated with the male sex, and the unbranched form with the female. This view is not supported by any direct evidence, nor, so far as I am aware, is any analogous case known; I consider, therefore, that the pinnate and the simple forms should by no means be united until their affinities are actually proved. It may also be remarked that *S. inflata* is not always pinnate, though unbranched forms have not hitherto been referred to it; the *S. brevicyathus*, found by Versluys in the same dredging with his *S. inflata*, is almost certainly merely an unbranched form of the latter species; and in my own specimens, which agree absolutely with *S. inflata* (so far as can be ascertained in the absence of the gonosome), I find simple and pinnate shoots growing from the same hydrorhiza, or even, in one instance, the stem of a pinnate shoot running out into a stolon, which, in its turn, gives origin to an unbranched shoot. These simple forms differ from *S. loculosa* in the thinner perisarc, the more sharply triangular teeth, and the tendency (which is also exhibited by the pinnate form) for the ridge of the hydrotheca to become weaker, or sometimes quite obsolete, in the distal portions of the colony. But I doubt whether these distinctions are constant, and should not regard them as of specific value if the gonosome proved to be similar in each case.

S. brevicyathus is not distinguished from *S. inflata* except by the simple habit, and by points of structure known to be variable in the species of this group, such as the presence of a third tooth on the border of the hydrotheca.

Ritchie agrees with Congdon that the operculum of *S. inflata* has a large abcauline and two smaller latero-adcauline valves, but feels

assured that in *S. loculosa* (*turbinata* ?) the operculum is formed by a solitary flap. Probably the condition of the operculum would be determined by that of the hydrotheca-margin, which may or may not have the small superior tooth developed.

The species seems remarkably variable in size. The usual height is about half an inch, and according to Nutting often less, while specimens are recorded up to two inches. It is also said to vary greatly in the proportionate length of the internodes, as well as in the distinctness of the nodes. These in my specimens are all of the well-defined oblique type (sloping downwards from the back) so familiar in many Sertularians, and Ritchie describes his specimens as similar in this respect. Nutting, however, describes the nodes of the pinnae as straight, and Versluys says, "La partie distale de la pinnule est divisée plus ou moins distinctement en entrenœuds." The naked proximal part of the stem, which is divided from the hydrocladiate portion by a very marked joint, is much shorter in my specimens than in the type. I note the peculiarity mentioned by Allman and Ritchie of the pinnae falling off, leaving the basal portions as a series of pointed spines. Much variation exists in regard to robustness of texture, and to the distinctness of the transverse ridge.

Versluys first gave a satisfactory account of the species under the name of *Desmoscyphus inflatus* in 1899. Allman's *D. gracilis* was found by Nutting, from examination of type specimens, to be identical with Versluys' species, and as the name *S. gracilis* was preoccupied, Nutting re-named the species *S. versluysi*. Versluys' name, however, held priority till Billard later, on examining Allman's type, found that *S. amplectens* (1885) was also the same species. Afterwards Billard classed all these names, along with *S. flosculus* Thompson, *D. marginata* Kirchenpauer, and *S. loculosa* Busk, as synonyms of *S. turbinata* (Lamouroux). As I have for reasons already stated classed the two last-named species as at least provisionally distinct, I adopt for the pinnate form Kirchenpauer's name, *S. marginata*. Kirchenpauer's specimens, like my own, were without the gonosome. If, as is quite possible, our species should prove to have gonangia of a different type altogether, distinguishing it alike from *S. loculosa*, and from Versluys' species, it would be advisable to retain for it the name of *S. marginata*, and for the other form *S. amplectens*.

It may be noted that it is to the restricted *S. loculosa* that *S. marginata* exhibits, in the form of the hydrothecae, such close affinity. I have not seen it with the hydrothecae resembling those of *S. turbinata*.

SERTULARIA TENUIS Bale.

Sertularia tenuis, Bale, Aust. Hydr. Zooph., 1884, p. 82, pl. v., figs. 4, 5, pl. xix., fig. 16; Jäderholm, Ark. f. Zool., k. svenska Vetenskapsakad, i., 1903, p. 287; (?) Thornely, Rep't. to Gov't. of Ceylon on the Pearl Oyster Fisheries of the Gulf of Manaar, Suppl. Rep't. viii., 1904, p. 117, pl. ii. fig. 5.

Sertularia gracilis (in part), Pictet, Rev. Suisse de Zool., i., 1893, p. 48.

Thuiaria tenuis, Borradaile, Fauna and Geogr. of the Maldive and Laccadive Archipel., ii., 1905, p. 841.

Sertularia distans (in part), Billard, Arch. de Zool. Exp. et Gén., 4 sér., vii., 1907, p. 354; id., Expéd. Sci. du Travailleur et du Talisman, Hydroïdes, viii., 1907, p. 187, figs., 10, 11.

Not *Sertularia gracilis*, Hassall, Hincks, Brit. Hyd. Zooph., p. 262, pl. liii., fig. 2; Nutting, Amer. Hydr.—Sert., 1904, p. 57, pl. iii., fig. 10.

Not *Sertularia distans*, Allman, Gulf Stream Hydroids, 1877, p. 25, pl. xvi., figs 9, 10; Nutting (as *S. pourtalesi*), Amer. Hydr.—Sert., 1904, p. 59, pl. v., fig. 5.

Not *Dynamena distans*, Lamouroux, Hist. Polyp. Cor. Flex., 1816, p. 180. pl. v. fig. 1 a. b.

S. tenuis is mentioned here for the purpose of rectifying the synonymy, which has become confused owing to the association of the species with some others, which, however similar in the form of the hydrothecae, differ from it widely in other respects. Marktanner-Turneretscher first suggested its identity with a European form which he considered a variety of *S. gracilis*, and Pictet definitely stated that the two species were identical, overlooking the fact that the original description of *S. tenuis* was, in more than one point, obviously incompatible with the known characters of *S. gracilis*. In view of the same description it is difficult to imagine why Borradaile referred the species to the genus *Thuiaria*.

Billard accepted Pictet's statement, but having satisfied himself from his examination of Lamouroux' types that the *Dynamena distans* of that author was the same species as *S. gracilis*, ranked all these forms together, as well as the *S. distans* of Allman, and some other American species, which, however, Nutting considers distinct.

S. gracilis is a typical example of what Schneider calls the "*Dynamena*-group" of Sertularians; that is to say, it has the

hydrothecae in opposite pairs, and when branches are produced they spring from below (or sometimes above) one of the paired hydrothecae. Thus there is no difference in the arrangement of the hydrothecae on the stem and the branches, or as Nutting says we find "the stem and branches alike in every particular." This is obviously the simplest form of ramification possible, and is especially found among the *Diphasiae*. Now, from this arrangement *S. tenuis* differs entirely, and, so far as the ramification is concerned (though not otherwise), it agrees with Schneider's "*Thuiaria*-group," having each of the regular alternate pinnae springing from below an axillary unpaired hydrotheca, while the stem-internode supporting it supports also the normal pair, which in these circumstances are generally sub-alternate, the one on the same side as the pinna being set higher up. The arrangement is exactly the same as in *S. marginata* and numerous larger species, such as *S. elongata*, and by its differentiation of the stem and pinnae is of a more advanced type than that of *S. gracilis*. Besides the distinction between the three-celled internodes of the stem and the two-celled ones of the pinnae, there is the further difference that the hydrothecae of the stem are more divergent than those of the pinnae. Yet another distinction which has been overlooked is that *S. gracilis* has the nodes at distant and irregular intervals, while *S. tenuis* has them below every pair of hydrothecae (or every three hydrothecae in the case of the stem). Some species, however, are said to vary in this particular, and *S. tenuis* may possibly do so, but I have seen no instances, except in the special cases mentioned below.

While the pinnae, when present, are usually regular and alternate, the habit is not so firmly established as to preclude the occurrence of frequent irregularities. Thus it is not unusual to find the two lowest pinnae of a shoot on one internode and opposite (a condition, it may be remarked, which occasionally occurs in several other small alternately-branched species, both of *Sertularia* and *Plumularia*). The internode thus bears four hydrothecae, the two axillary ones and the regular pair, which are now opposite. Even on a pinnate stem there may be intercalated between two pinna-bearing internodes an internode supporting only a pair of hydrothecae. It is usual for the four or five internodes at the top of a pinnate stem to bear hydrothecae only, in which case this portion entirely resembles a pinna, the hydrothecae being opposite and becoming less divergent towards the summit. The simple shoots, which are the most numerous, have regular two-celled internodes, but the hydrothecae (except at the top) are widely divergent, like those

on the stems of the pinnate form, except that they are opposite and generally in contact in front. I have seen an abnormal case of a hydrotheca being transformed and continued as a branch. The hydrotheca-bearing portion of the pinna is separated from the cladophore by a short internode, exactly as in *S. marginata*.

The gonangia are pear-shaped, tapering below, not compressed, but circular in section, and with the outline towards the summit somewhat concave outwardly, thus differing from the "round-shouldered" compressed form found in certain species otherwise very closely allied to *S. tenuis*.

SERTULARIA DIVERGENS Busk.

Sertularia divergens, Busk, Voy. of Rattlesn., i., 1852, p. 392; Bale, Aust. Hyd. Zooph. 1884, p. 81, pl. v., fig. 3, pl. xix., fig. 16; Billard, Ann. Sci. Nat. 9 sér., ix., 1909, p. 322.

Not *Dynamena divergens*, Lamouroux, Hist. Polyp. Cor. Flex., p. 180, pl. v., fig. 2.

(?) Not *Sertularia moluccana*, Pictet. Rev. Suisse de Zool. i., 1893, p. 50, pl. ii., figs. 42, 43.

This species or variety differs from *S. tenuis* in the more compact habit, the shorter hydrothecae and internodes, and the closer pinnae, which are somewhat more divergent. The pinnate habit seems more confirmed; indeed, I have not yet observed any of the unbranched shoots which in *S. tenuis* predominate, though such will doubtless occur.

Pictet considered his *S. moluccana* a variety of this species, but he renamed it because he regarded it as distinct from Lamouroux' species. I do not think *S. moluccana* is the same, judging by Pictet's figure. He mentions that the ramification agrees with my description, but the ramification is common to many other species.

The investigations of Billard confirm the opinion expressed by Pictet, and earlier by myself, that this is not the *D. divergens* of Lamouroux, but as that species is the same as *S. bicuspidata*, Lamarck, which name Billard has adopted, the name may stand as *S. divergens*, Busk, unless it be treated, as Billard with much reason proposes, as a mere variety of *S. tenuis*.

SERTULARIA ACANTHOSTOMA Bale.

Sertularia acanthostoma, Bale, Journ. Micr. Soc. Vict., ii., 1881, p. 23, pl. xii., fig. 4; id., Aust. Hydr. Zooph., 1884, p. 85, pl. iv., fig. 7, 8; Billard, Arch. d. Zool.

Exp., 4 sér., vii., 1907, p. 352; Bartlett, Geelong Naturalist, 2 ser., iii., 1907, p. 44, fig. —; Warren, Ann. Nat. Gov't. Museum, i., 1908, p. 303, fig. 7, pl. xlvi., figs. 23-26.

Billard has pointed out that in this species there are not always three pairs of hydrothecae between every two pairs of pinnae, as stated in the original description, but that the number varies, three, however, being the rule. I have noticed a similar irregularity in a Portland specimen given to me by Mr. Maplestone, which has four pairs in some of the intervals, thus agreeing with the majority of cases in which Billard found a departure from the typical number. I have also met with a specimen in which the stem, consisting of thirteen internodes, was unbranched throughout.

Warren mentions that his Natal specimens were usually covered with a delicate algal incrustation. This organism is also very commonly found on Australian specimens.

S. pluridentata (Kirchenpauer), another African species, is remarkably similar to the present in the general form of the hydrothecae. The pinnae, however, are not opposite, but, according to Kirchenpauer, irregular. The denticulation of the hydrotheca-border appears to agree with that of *S. acanthostoma* in so far that it is symmetrical on the two sides of the hydrotheca, but the teeth differ both in number and arrangement, *S. acanthostoma* having sixteen, while *S. pluridentata* has only eight. These eight are arranged precisely like those of many Statoplean Plumularians; that is to say, there is a median unpaired tooth on the adcauline extremity of the border, and a similar one on the apocauline margin, while each of the intermediate sides supports three teeth, thus making two unpaired teeth and three pairs. In *S. acanthostoma* there are no median teeth on either the adcauline or the apocauline margins, but the teeth are arranged in eight symmetrical pairs on the two sides. Warren's figure of the hydrotheca, seen from above, presents a quite striking resemblance to the front view of *Halicornaria ilicistoma*, in which also the teeth are arranged, some pointing inward and others outward.

Dr. Warren has furnished interesting details of the structure, pointing out especially that in the concave depression at the outer margin of the hydrotheca there is a thickening of the ectodermal epithelium, which has very much the character of a nematophore, being provided with a battery of large nematocysts similar to those found in the Plumularians. He also remarks that the hydrotheca is distinguished by possessing no trace of operculum.

The gonothecae have only been observed by Bartlett. They are described as "long, obovate, smooth, aperture operculate." They are of unusually long proportions, widest a little above the middle and but little narrowed above; the operculate aperture seems to be the full width of the top, and no collar is shown. The height, according to Bartlett's figure, is about 2 mm., by 1 mm. in diameter.

Sertularia muelleri, n. sp. (Plate XII., Figs. 1–5.)

Shoots thickly clustered, simple, nearly half an inch in height, slender, divided by conspicuous oblique joints into internodes, each of which supports a pair of hydrothecae about the middle.

Hydrothecae opposite, in contact in front, separated behind, tubular, divergent, but with the distal part curved upward; aperture very large, looking upward, with two long pointed teeth, one in front, the other, which is slightly larger, on the back outer margin.

Gonothecae borne on the proximal part of the shoots, mostly 2-4 on each; ovate, somewhat compressed, very high-shouldered; orifice small, operculate, with a narrow denticulate collar.

Hab.—Encounter Bay.

This species has some affinity with *S. minima*, but the internodes are considerably longer and more attenuated, the hydrothecae have the aperture more expanded, looking more upward and with longer teeth, and there is a characteristic curve upward of the outer side of the hydrotheca at the top. To a certain extent they resemble the hydrothecae of *S. operculata*. The gonangia are of the same general type as those of *S. minima*, but rather irregular, many of them having the shoulders very high and somewhat angular. The shoots are produced in great profusion, a slender linear alga ten inches long, being thickly clothed with them from end to end.

The specimen was given to me by the late Baron von Mueller.

Plumularia campanula Busk.

Plumularia campanula, Busk, Voy. of Rattlesn., i., 1852, p. 401; Bale, Aust. Hydr. Zooph., 1884, p. 124, pl. x., fig. 5; id., Proc. Lin. Soc. N.S.W., Ser. 2, iii., 1888, p. 776, pl. xx., figs. 1-6; id., Tr. and Proc. Roy. Soc. Vict., xxiii., 1887, p. 94; id., Proc. Roy. Soc. Victoria, vi., N.S., 1893, p. 113; Marktanner-Turneretscher, Ann. d. k. k. Naturh. Hofmuseums, v., 1890, p. 255; Farquhar, Trans. N.Z. Inst., xxviii., 1896, p. 466; Billard, C. R. Acad. d. Sci., cxlvii., 1908, p. 759.

Plumularia indivisa, Bale, Journ. Micr. Soc. Vict., ii., 1881, p. 39, 46, pl. xv., fig. 1.

Plumularia laxa, Allman, Chall. Plum. 1883, p. 19, pl. i., figs. 5, 6.

Plumularia torresia, Von Lendenfeld. Proc. Lin. Soc. N.S.W., ix., 1884, p. 477, pl. xiii., figs. 13, 14, pl. xiv., fig. 16.

Plumularia rubra, Von Lendenfeld, Proc. Lin. Soc. N.S.W., ix., 1884, p. 476, pl. xiii., figs. 11, 12, pl. xiv., fig. 15.

The simple form of this species was described by me in 1881 under the name of *P. indivisa*, but it was mentioned in an addendum that it had been found to be identical with the stemless form described by Busk. It is introduced here for the purpose of rectifying its erroneous association by several writers with the widely-distributed *P. secundaria*, consequent on Dr. Billard's report that Busk's type specimen in the British Museum was the same as that species. This statement is doubtless correct, being confirmed in letters from both Dr. Billard and Dr. Kirkpatrick, nevertheless Busk's account shows clearly that the specimens which he had before him were not *P. secundaria;* moreover, my specimens agree precisely with those described by Busk. Obviously this is an instance, like others I have met with, in which the museum specimen is erroneously labelled; and in this case the confusion is not surprising, as the two forms cannot be distinguished from each other without microscopical examination, and, as I have now ascertained, both are found in the same locality.

Under the microscope the two hydroids are easily distinguished. The short, stout, rigid or semi-rigid lateral sarcothecae of *P. campanula* and its stemless variety, are in themselves sufficient to mark it as distinct from any species with the long, wine-glass-shaped cups found in *P. secundaria*, *P. catharina*, etc., as Busk points out. Other differences are the presence in *P. secundaria* of a very small sarcotheca behind the hydrotheca, not found in *P. campanula*, and also the presence of one, two, or three, but generally two, median sarcothecae on the upper part of each internode, where *P. campanula* has only one.

The ramification of *P. campanula* is very variable. First we have the *indivisa*-form, in which simple hydrocladia spring directly from the hydrorhiza. Among these we find shoots which give origin to one, or perhaps two, secondary hydrocladia. From these the transition is easy to regularly pinnate forms, such as constitute the *P. rubra* of Von Lendenfeld; and thence to the polysiphonic

branched form described by Von Lendenfeld as *P. torresia*, and by Allmann as *P. laxa*. These forms also frequently bear additional hydrocladia springing at irregular intervals from the regular pinnately-disposed series.

PLUMULARIA BADIA Kirchenpauer.

Plumularia badia, Kirchenpauer. Abh. Nat. Ver. Hamb., vi., 1876, p. 45, pl. i., iv., fig. 3; Bale, Catal. Aust. Hyd. Zooph., 1884, p. 128, pl. xviii., figs. 1-2.

Plumularia ramsayi, Bale, Cat. Aust. Hydr. Zooph., 1884, p. 131, pl. xi., figs. 3, 4; id., Proc. Lin. Soc. N.S.W., Ser. 2, iii., 1888, p. 746; Kirkpatrick, Sci. Proc. Roy. Dubl. Soc., vi., (N.S.), 1890, p. 604.

Plumularia gracilis, Von Lendenfeld, Proc. Lin. Soc. N.S.W., ix., 1884, p. 476, pl. xiv., fig. 17, pl. xvii., figs. 28, 29.

Dr. Hartlaub has kindly examined, at my request, the type specimens of Kirchenpauer's *P. badia*, and has found them to be, as I suspected, identical with *P. ramsayi*. The point into which the anterior lip of the hydrotheca is, according to Kirchenpauer, produced, is not really present, neither are the other features by which the species appeared to be distinguished from *P. ramsayi*. So far from being produced as shown, the front of the hydrotheca is really somewhat everted, though very slightly.

AGLAOPHENIA BREVIROSTRIS (Busk). (Plate XIII., Figs. 7, 9.)

Plumularia brevirostris, Busk, Voy. of Rattlesn., i., 1852 p. 397.

Aglaophenia brevirostris, Bale, Aust. Hyd. Zooph., 1884, p. 169; Kirkpatrick, Sci. Proc. Roy. Dubl. Soc. vi. (N.S.), 1890, p. 611; Billard, C. R. Acad. d. Sci., cxlviii., 1909, p. 368.

Thecocarpus brevirostris, Billard, Ann. Sci. Nat., 9 ser., xi., 1910, p. 51, fig. 24.

Aglaophenia heterocarpa, Bale, Journ. Micr. Soc. Vict., ii., 1881, p. 30 (note).

Aglaophenia vitiana, Bale, Aust. Hydr. Zooph., 1884, p. 152.

Aglaophenia maldivensis, Borradaile, Fauna and Geogr. of the Mald. and Laccad. Archip., ii., 1905, p. 843, pl. lxix., figs. 8-8b.

Not *Plumularia* (for *Aglaophenia*) *vitiana*, Kirchenpauer, Abh. Nat. Ver. Hamb., v., 1872, p. 34, pl. i. iii., fig. 9; Billard, Arch. Zool. Exp. et Gén., 4 Sér., vii., 1907, p. 388, figs. 22, 23.

Hydrophyton about one inch in height, polysiphonic in the older portions only, and small specimens monosiphonic throughout; branched or unbranched, branches when present all in one plane, given off at very wide angles from the supplementary tubes; internodes normally supporting each a hydrocladium, but the nodes often indistinct. Hydrocladia straight, alternate, divergent at a wide angle (about 65 deg.) in one plane, nodes transverse, dorsum of hydrocladia slightly serrate.

Hydrothecae borne on the front of the hydrocladia, tubular, more or less abruptly bent in the middle (proximal and distal extremities being bent away from the hydrocladium); a rudimentary ridge or fold near the base, directed obliquely forward; aperture expanding, border with a large strongly-incurved anterior tooth, two large triangular teeth on each side, and two angular lobes above the lateral sarcothecae; back entire, adnate. A very slight septal ridge generally present, opposite the intrathecal fold.

Mesial sarcothecae free for about half their length, embracing the whole of the proximal part of the hydrotheca, and then projecting forward over the aperture; with a small circular terminal orifice and a larger inferior one adjoining the hydrotheca, the two united by an inconspicuous slit; an additional orifice opening into the hydrotheca. Lateral sarcothecae small, sub-conical, directed forward or downward and somewhat outward, terminal and lateral apertures generally united. Cauline sarcothecae with wide, free distal margin, two at the base of each hydrocladium. A minute apparent perforation on each hydrocladium-process.

Gonangial ramules with a normal hydrotheca on the first internode; corbula consisting of about five pairs of leaflets with lobed edges, which are united by the lobes, leaving a series of small openings between them; rows of sarcothecae very irregularly placed, those nearest the rachis mostly bordering the distal edges of the leaflets, but those higher up in short rows, not at the edges; each leaflet with a large sinus near the base on the distal side, in which is seated a small hydrotheca with its two lateral sarcothecae. Rachis generally produced beyond the corbula, its terminal portion supporting about two somewhat modified hydrothecae.

Colour, light brown.

Hab.—Fiji, on a coral: off Cumberland Ids., 27 fathoms (Busk): Torres Strait (Haddon): on the reef at Hulule, Male Atoll (Borradaile).

Busk's original description of *P. brevirostris* was insufficient to admit of its identification, but Dr. Kirkpatrick kindly compared one of my specimens with Busk's type, and has also sent me a specimen from Haddon's Torres Strait collection, which proves similar in all respects to my own specimens from Fiji. These I described in 1881 under the proposed name of *A. heterocarpa*, but I afterwards referred them to the *A. vitiana* of Kirchenpauer ("Catalogue," p. 152). The later descriptions by Billard of both *A. vitiana* and *A. brevirostris* seem to prove, however, that this reference was erroneous.

Nevertheless, the two species have many points of agreement. Both were found growing on a coral from Fiji; in size, habit, and colour they agree closely, as well as in some minor particulars. The branches in each species spring from the supplementary tubes, so that branching cannot occur till the polysiphonic structure is developed, which in many cases is not till growth is well advanced. One of my specimens of *A. brevirostris* consists of a single shoot bearing five corbulae, but with no trace of fasciculation. The proximal part of the stem is naked at first, then supporting a few large sarcothecae in a single row before the hydrocladia are reached.

The principal distinction between the hydrothecae of the two species is that in *A. vitiana* there is an anterior intrathecal ridge similar to that of *Lytocarpus phillipinus*, while in *A. brevirostris* the distal part of the hydrotheca, though abruptly recurved, does not become united to the proximal portion, so that instead of an intrathecal ridge there is on the apocauline side of the hydrotheca a deep constriction. In *A. vitiana* the two principal teeth on each side of the hydrotheca are said to be bifid, and the internode is described as having three septal ridges, or sometimes only two. *A. brevirostris* has the lateral teeth simply triangular, and there is scarcely ever more than one septal ridge, which subtends the inthrathecal fold. In *A. vitiana* the internodes are stouter, as is the mesial sarcotheca, and the canaliculate condition of the latter is more apparent.

Both Billard's and Borradaile's figures show the constriction of the hydrotheca as much less abrupt than is usually the case. In Haddon's specimen, as well as in my own, such hydrothecae are abundant, but in both cases the majority are of the more abruptly bent type.

A singular condition noted by Billard as occurring in *A. vitiana* and *Idia pristis* is observable also in *A. brevirostris*, namely, the reversal of the front and back of the polypidom. I have once observed the same thing in *A. sinuosa*, but it would seem to be a common occurrence in *A. brevirostris*, as it is found in more than one of my few specimens. In one instance a branch has the hydrocladia up to about the middle all fronting one way, suddenly a reversal occurs, and the hydrocladia face in the opposite direction; this continues for a distance including four hydrocladia on each side, and then a second reversal takes place, and on the rest of the branch the hydrocladia face as at the beginning. In another case the part of the shoot including the first five hydrocladia faces one way, and the remainder in the opposite direction. Billard found that these reversals followed a regeneration of a broken part; in my specimens, however, this did not appear to be the cause, as I could find not the slightest breach of continuity in the branches.

The corbulae of *A. brevirostris* are interesting structures, combining, as I pointed out in 1881, the general character of the *A. pluma* type with the presence of hydrothecae on the leaflets. The attachment of the leaflets to each other by the marginal lobes, leaving small interstices between, is a feature found also in the corbulae of *A. macrocarpa*. Another noteworthy feature is the continuation of the gonocladium beyond the corbula, where it resumes for a short distance the character of a hydrocladium, supporting one or two hydrothecae.

LYTOCARPUS AURITUS (Busk). (Plate XIII., Fig. 10).

Plumularia aurita, Busk, Voy. of Rattlesn., i., 1852, p. 397.

Aglaophenia aurita, Bale, Aust. Hydr. Zooph., 1884, p. 169, pl. xviii., figs. 18, 19.

Lytocarpus phœniceus auritus, Billard, C. R. Acad. d. Sci., cxlviii., 1909, p. 367; id., Ann. d. Sci. Nat., 9 sér., xi., 1910, p. 49.

Aglaophenia disjuncta, Pictet, Rev. Suisse de Zool., i., 1893, p. 59, pl. iii., figs. 51, 52.

Hydrophyton 2-3 inches in height, polysiphonic in the older portions only, and small specimens monosiphonic throughout, branched or unbranched; branches when present all in one plane, given off almost at right angles from the supplementary tubes, each internode normally supporting a hydrocladium, but the nodes often indistinct. Hydrocladia straight, alternate, divergent at a wide

angle (about 75 deg. to 80 deg.), and a little directed towards the front; nodes transverse or scarcely oblique, indistinct.

Hydrothecae borne towards the front of the hydrocladia, with which their longest diameter is parallel, a slight constriction near the base on the adcauline side, continued into a slight transverse fold; an anterior intrathecal ridge projecting downwards from between the front of the aperture and the mesial sarcotheca more than half-way through the cell; aperture at a small angle with the hydrocladium, sub-crenate, sub-plicate, each side forming an angular lobe, front entire, a rounded lobe or an erect tooth behind. Hydrothecal internode with two divergent septal ridges, one nearly opposite the rudimentary posterior ridge, the other at the base of the lateral sarcothecae; generally a third midway between them.

Mesial sarcotheca adnate to the front of the hydrotheca nearly as far as the aperture and mainly rising from it, free part variable in length, slightly tapering, projecting forward at a varying angle, with distinct terminal and inferior apertures and a small orifice opening into the hydrotheca. Lateral sarcothecae conical or tubular, either adnate and directed upwards, or large, free and projecting downwards from the hydrotheca; terminal and lateral apertures distinct. Cauline sarcothecae similar to the laterals, but wider, two at the base of each hydrocladium.

Gonosome?

Colour, bright brown.

Hab.—Port Darwin Telegraph Cable: off Cumberland Island, 27 fathoms (Busk): Bay of Amboyna, 80 metres (*A. disjuncta*, Pictet).

This species, like *A. brevirostris*, was insufficiently described by Busk, and remained unidentified until 1909, when Billard examined Busk's type in the British Museum, and found its structure to agree with that of *L. phœniceus*. But the habit is different; Busk says that the branches are at right angles to the stem, and that the habit closely resembles that of *A. brevirostris* (where the hydrocladia also form a wide angle with the rachis), while in all the varieties of *L. phœniceus* observed by me the branches, and also the hydrocladia, are set at angles of about 45 deg. *L. auritus* may therefore be described as having the habit of *A. brevirostris* with the minute structure of *L. phœniceus*, and this description applies to a small specimen which I have had for many years, but which I had always hesitated to assign to *L. phœniceus* (notwithstanding the similarity of the hydrothecae), on account of the different habit. It was still in the monosiphonic stage, and, therefore, unbranched, and was collected from the Port Darwin cable, where it was growing

in company with fertile specimens of *L. phœniceus*. That the type specimen is similar is evident from the statement of Dr. Kirkpatrick, who writes, "*A. aurita* seems to me to be a variety of *A. phœnicea*. The hydrothecae are identical, but the hydrocladia more separated and at a wider angle."

I have a sketch by Mr. Busk, showing the ramification only. It represents a colony an inch and a half high, which divides just above the base into three ascending stems, each of which gives origin to two or three branches on each side, the branches being, as Busk describes, "not opposite nor regularly alternate, divaricate at right angles." (The "right-angled" condition is only approximate). Pictet's figure of his *A. disjuncta* agrees perfectly with Busk's account and sketch.

As to the form of the hydrotheca Billard finds that Busk's specimen resembles most closely the form of *L. phœniceus* figured by me on plate xv., fig. 5, of the "Catalogue," but with the median tooth less developed. My specimen differs from this in having the crenation or plication of the hydrotheca-margin much feebler, also in having the lateral sarcothecae of the erect type, while those of the figure cited are directed downward. Some at least of Busk's specimens must have agreed with mine, since he describes the lateral sarcothecae as rising above the hydrotheca. Pictet's specimen also agrees in this particular, as well as in the feeble plication of the hydrotheca-margin. It seems, therefore, that the wide range of variation found in the hydrothecae of *L. phœniceus* is paralleled in *L. auritus*, and that Billard's suggestion to establish *auritus* as a variety based on a particular form of hydrotheca will scarcely be applicable. The variety or species should be founded on the peculiar habit, by which *L. auritus* is distinguished from all the forms of *L. phœniceus*.

Pictet's description and figure of his *A. disjuncta* agree so closely with *L. auritus* that I think there can be little doubt of their identity. The only points in which a distinction is indicated are the position of the hydrocladia in the same plane, and of the hydrothecae, which are said to face the front exactly. Both these descriptions as applied to my specimen are only approximately correct, but the differences are negligeable. The distance apart of the hydrothecae, which is the feature regarded by Pictet as of principal importance, is not greater than in one or two forms of *L. phœniceus* in my possession.

HALICORNARIA ARCUATA (Lamouroux). (Plate XIII., Figs. 1-4).

Aglaophenia arcuata, Lamouroux, Hist. Polyp. Cor. Flex., 1816, p. 167, pl. iv., fig. 4a, b; Kirchenpauer, Abh. Nat. Ver. Hamb., v., 1872, p. 27, pl. i., fig. 10.

Plumularia arcuata, Lamarck, An. s. Vert. 2nd Ed. ii., 1836 p. 166.

Aglaophenia arquata, Krauss, Coral. u. Zooph. d. Sudsee, 1837, p. 24.

Halicornaria arcuata (in part), Billard, Arch. d. Zool. Exp., 4 sér., vii., 1907, p. 366, fig. 13; Stechow, Zool. Jahrb., xxxii., 1912, p. 369.

Halicornaria cornuta, Allman, Journ. Lin. Soc. Lond., Zool., xix., 1886, p. 153, pl. xxiii., figs. 1-4.

Hydrocaulus monosiphonic, unbranched or dividing dichotomously one or more times; hydrocladia alternate, one on each internode, set at an angle of about 45 deg. to 50 deg., and slightly directed forward; nodes slightly oblique.

Hydrothecae cup-shaped, deep and narrow, set at a wide angle (about 75 deg. to 80 deg.), no true intrathecal ridge, but the apocauline wall somewhat incurved at the point where it is interrupted by the hydropore, which is large and distinct; aperture with a strong median anterior incurved tooth and usually with three teeth on each side, of which the first and third are large and everted, while the middle one is small and incurved, the latter often more or less obsolescent or totally wanting; back produced upward into a long erect lobe with the edges curved towards each other on the outer side, hydropore with one or two minute denticles above and below. No septal ridges in the internode.

Mesial sarcotheca quite erect in the proximal portion, distal half directed forward, either parallel with the hydrocladium or more obliquely; free part compressed laterally, very stout at the part just above the hydrotheca, where the strongly salient aperture is situated, terminal portion tapering very rapidly to the acute closed point. Lateral sarcothecae adnate, saccate, with two small circular apertures close to the free margin, the lower one becoming, in those near the end of the hydrocladium, produced into a large tubular mouth, or even into a long closed pointed horn, having its own lateral aperture, while the upper circular orifice becomes obsolete. Cauline sarcothecae similar to the laterals, two, close together, at the base of each hydrocladium in front, and one at the back of each axil.

Gonosome?

Colour, brown ("fauve brillant et foncé"—Lamouroux).

Hab.—Mer des Antilles (Lamouroux): Algoa Bay and Algiers (Krauss): Fort Dauphin, Madagascar (Billard): Cape of Good Hope (Kirchenpauer).

This African species, which is not known to occur in Australia, is introduced here on account of Billard's having referred to it our *H. ascidioides*, which indeed singularly resembles it in several particulars, but which, as I shall show, is nevertheless quite distinct.

The form which is described above (from specimens obligingly forwarded to me by Dr. Stechow from the Munich Museum) is, I have no doubt, the true *Aglaophenia arcuata* of Lamouroux and Kirchenpauer (also the *Halicornaria cornuta* of Allman), but Billard includes with it several forms which he considers to be the young colonies, and which, if really to be referred to the same species, stamp it as variable to an extent unknown elsewhere in the order. I have not seen these forms, some of which appear scarcely to differ from our *H. longirostris*, and the specimens sent to me, which include young colonies of only two centimetres in height and mature ones of eleven or twelve, do not differ noticeably among themselves. When the mesial sarcotheca is carried forward parallel with the hydrocladium they agree roughly with Lamouroux' figure, when it is more oblique they approximate to Kirchenpauer's.

According to Lamouroux' figure the hydrocaulus is dichotomously divided several times, but from Billard's account the ramification is peculiar and probably unique; a branch springs from the front of the hydrocaulus, and has its anterior aspect directed towards that of the stem, and each successive branch grows in the same manner. The result of this mode of branching appears to be that all the branches are in one plane, but in a plane at right angles to that of the hydrocladia. This may be contrasted with the condition which prevails in *H. furcata* and its allies, where the hydrocaulus bifurcates in a single plane, which is also the plane of the hydrocladia. According to Lamouroux' figure the branches diverge at a very wide angle (about 90 deg.).

Billard states that in young colonies the cauline internodes are longer than wide, and nearly cylindrical, while in mature colonies the side of the internode on which the hydrocladium is borne is about double the length of the opposite side. The latter description applies to all my specimens, young and old, except that the difference in length of the two sides is not so great. The internodes are

very short, and the one side being longer than the other it follows that the nodes are oblique, alternately sloping to the right and the left, so that the internode, as seen from the back or the front, appears cuneate.

Billard's description of the hydrothecae in mature colonies is as follows:—"Enfin dans les colonies âgées la région proximale et moyenne des hydroclades montre des hydrothèques dont le bord présente trois dents latérales, la première et la troisième étant rejetées vers l'extérieur, et la dent moyenne dirigée vers l'intérieur; dans la partie distale la dent moyenne qui se réduit au fur et à mesure qu'on s'élève a disparu complètement et il n'existe plus que deux dents latérales; de plus les dactylothèques latérales sont trés allongées et atteignent jusqu'à 160μ. On a ainsi un dessin qui concorde en tous points avec celui donné par Allman pour son espèce *Halicornaria cornuta*, et celle-ci ne se distingue pas de l'espèce de Lamouroux.

"Les hydrothèques de ces colonies agées montrent une dent postérieure extrêmement développée; parfois elles possèdent un repli intrathécal; la présence de cette particularité permet de faire entrer en synonymie l'*Halicornaria ascidioides* Bale. qui possède les mêmes caractères. Les dactylothèques médianes sont plus fortes dans ces colonies âgées, elles sont ouvertes ou bien parfois fermées à leur extrémité et il en est de même des dactylothèques latérales allongées."

The foregoing extract describes my specimens (both young and old) exactly, with these exceptions—the lateral sarcothecae are not usually so much elongated as described, the mesial sarcothecae are in no case open at the ends, and there is no intrathecal ridge, at least not such as *H. ascidioides* possesses, as will be presently explained.

Billard says that the gonosome is unknown. Krauss, however, mentions it in the following terms:—"Junge Exemplare haben eben so einseitig in den Achseln der Fiederchen sitzende grössere weibliche Zellen (sogenannte Bläschen). Am Strande ausgeworfen, verliert diese Aglaophenia bald ihre Fiederchen, während ein Theil der weiblichen Zellen hängen bleibt und erhält dadurch ein so verändertes Ansehen, dass Mann eine ganz andere Art vor sich zu haben glaubt." Unfortunately no description of these gonangia is given.

In comparing this species with *H. ascidioides* I may premise that I am unable to find a branched specimen of the latter, though I am under the impression that I have seen one. It is so extremely

close an ally of *H. superba* that there is every probability that its ramification would be similar; that is to say, a true branching, not a dichotomous division. A definite distinction is seen in the arrangement of the hydrocladia; those of *H. arcuata* are borne each on a separate internode, and are consequently always alternate, while in *H. ascidioides* every internode bears two hydrocladia, which are always opposite or nearly so. The hydrothecae of *H. arcuata* differ in form from those of *H. ascidioides*, being narrower towards the base, and are more erect, the central axis of the latter being at about 60 deg. to the internode, while that of the former is about 80 deg., the anterior side being indeed almost or quite at a right angle. The hydropore in *H. arcuata* is more conspicuous than in most species, owing to the perisarc being thickened up to the edge of the pore, so that the abrupt interruption is very noticeable in optical section. The slight ridge or projection inside the apocauline wall of the hydrotheca is caused by this thickened edge being more or less incurved just where it borders the hydropore on the upper side, and is therefore not analogous to the intrathecal ridge in *H. ascidioides* (and all the members of its group), which is a distinct septum, springing from the wall of the hydrotheca and projecting half across its cavity, and which does not border the hydropore but is situated some distance above it. Such a ridge is truly "intrathecal," while the ridge in *H. arcuata* is not *within* the hydrotheca at all, but is merely a portion of its boundary. At the same time there is no doubt that this rudimentary ridge indicates how the fully-developed ridge of such species as *H. ascidioides* has originated. The inflection of the hydrotheca-wall has been extended till it reached half across the cell, and then the inflected portions have been brought into contact and united. But this extension could not occur in a form like *H. arcuata*, unless the hydropore were removed away from the ridge to a lower position, as in the other species. While in most members of the genus the hydropore is much less conspicuous than in *H. arcuata*, its whereabouts is easily discernible (where the specimen is clean) by the little points of perisarc which project from its upper and lower margins. These denticles are a character which I have found common to all the species of *Halicornaria* which I have yet observed. In *H. arcuata* they are less conspicuous than in most species, but one or two can generally be made out, at least on the upper border of the hydropore, which, in this species, is the "ridge."

In regard to the hydrotheca-margin the two species differ notably. Both have an anterior tooth and one on the back, but the latter in

H. arcuata is much larger and has the edges turned outwards and recurved till it often appears quite tubular. The lateral teeth, however, are the most distinctive. There are normally three on each side; in *H. ascidioides* the middle one is always the largest (or at least as large as either of the others), and is always more or less everted, as are also the first and third. In *H. arcuata*, on the contrary, the middle tooth is the smallest, and is incurved, while the first and third are everted. In both species the lateral teeth may be reduced to two on each side, but in *H. arcuata* this results from the gradual disappearance of the incurved middle tooth, in *H. ascidioides* it is always the third tooth which becomes obsolete. In all the Australian species of the *ascidioides*-group the rule holds good that the middle lateral tooth is the principal one; in some cases the first may become obsolete, in others the third, and in others again both the first and third, but the middle one is in every species well developed, and always everted. The obsolescence of the middle tooth in *H. arcuata* becomes more pronounced towards the ends of the hydrocladia, but I do not find this to be the case with the decrease of the third tooth in *H. ascidioides*, the hydrothecae near the ends often having the teeth best developed.

The mesial sarcothecae of *H. arcuata* differ from those of *H. ascidioides* by the more erect proximal portion, the much more pronounced tapering of the free portion, and the closed pointed ends. I have never seen the ends closed in *H. ascidioides*, except in certain deformed specimens, where they were bluntly rounded. The lateral sarcothecae of *H. ascidioides* are never, so far as I have seen, prolonged into long closed horns as in *H. arcuata*, though as in many other species the tubular mouth is considerably elongated towards the ends of the hydrocladia. Only on the proximal part of the hydrocladia in *H. arcuata* are the little circular orifices equally developed, the lower ones become progressively more and more prominent towards the ends of the hydrocladia, where they attain the condition of rather long open tubes, or even pointed horns. In either case they have a lateral orifice on the inner side, and the upper of the two circular orifices has disappeared.

I have figured *H. ascidioides* along with *H. arcuata* for comparison. (See plate XIII).

HALICORNARIA SUPERBA Bale.

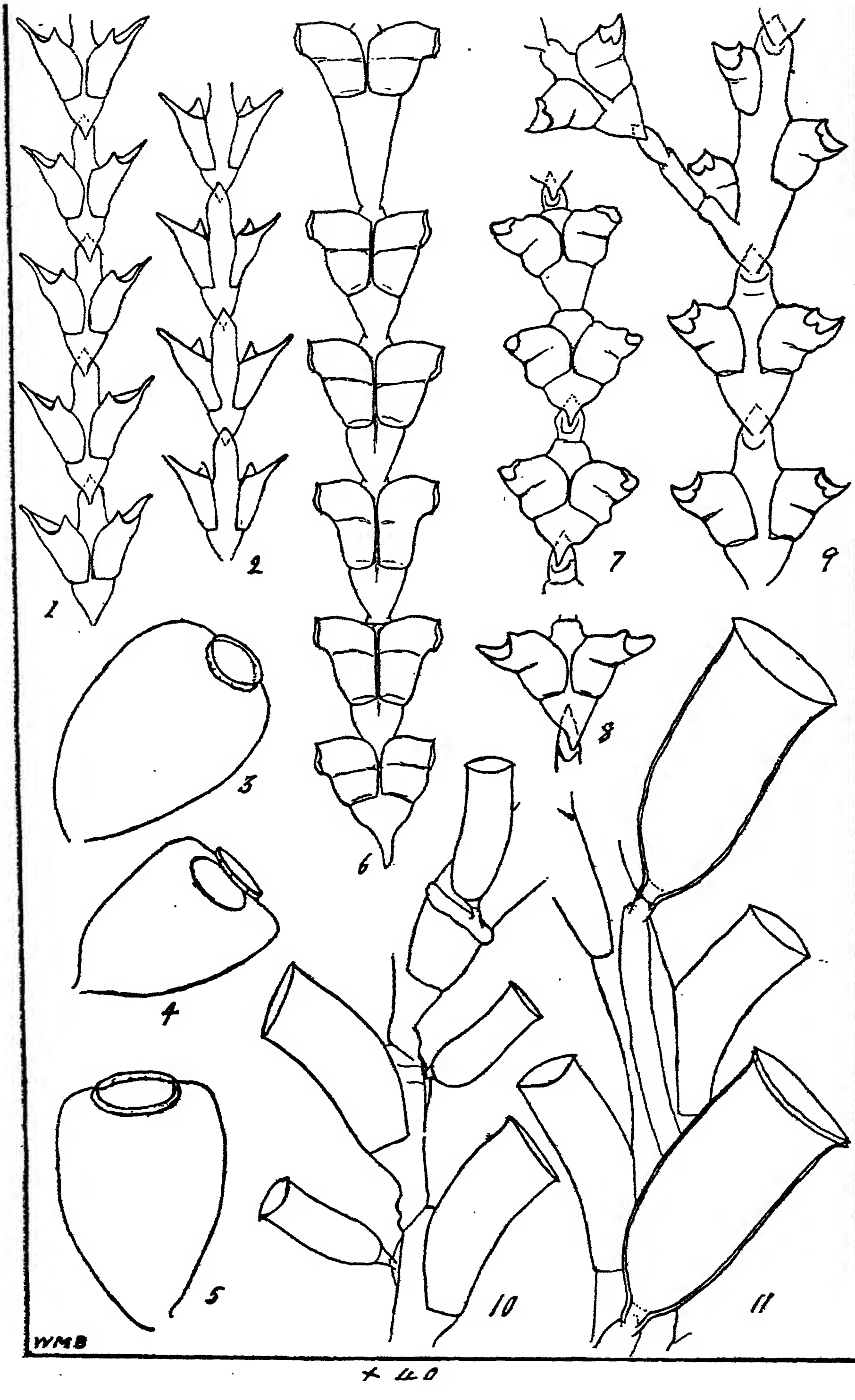
Aglaophenia superba, Bale, Journ. Micr. Soc. Vict., ii., 1881, p. 31, 45, pl. xiii., fig. 4-4b.

Halicornaria superba, Bale, Aust. Hydr. Zooph., 1884, p. 175, pl. xiii., fig. 1, pl. xvi., fig. 4; id., Proc. Roy. Soc. Vict., vi., N.S., 1893, p. 107.

I mention this species for the purpose of describing its mode of branching, and, incidentally, of contrasting it with the very different ramification of other members of the same section. The six or seven species in question form a very natural group, distinguished from all our other species (except *H. birostrata*) by the possession of a strongly-developed anterior ridge, and from all our other Statoplea by the position of that ridge. The minor characteristics of this group enable us to divide it into three sub-groups, the first consisting of *H. ascidioides* and *H. superba*, which are very intimately allied; the second of *H. baileyi*, *H. furcata*, and *H. intermedia*, which approximate even more closely; and the third of *H. hians* and *H. haswellii*, which also are nearly akin.

I have not seen either of the two last-named species in a branched condition, and though I believe I have seen a branched specimen of *H. ascidioides*, I cannot find one for reference. I have, however, several such specimens of *H. superba*, the ramification of which is quite different from that of *H. baileyi* and its two allies. In these latter there are strictly speaking no *branches*, every subdivision being purely dichotomous (resulting in general from the bifurcation of a single internode); the two new divisions are of equal diameter, each diverges at about the same angle from the primary axial line, and the perisarc is not interrupted at the bifurcation, but continuous, and even the regular spacing of the hydrocladia along the outer sides of the hydrocaulus is not interfered with.

H. superba is generally unbranched, but here and there among a large cluster is found a shoot giving off a small branch, or some times two, and in one case I found three. In many instances these branches sprang from the lower part of the stem, where it was denuded of hydrocladia, and were themselves bare on the proximal portion. There is no dichotomous arrangement, but a perfect distinction is maintained between stem and branches, the latter being smaller, and divergent abruptly from the side of the stem; indeed, they mostly start out at a right angle, though very soon curving upwards. The perisarc in their proximal portion is divided into internodes, much more strongly marked than the internodes of the hydrocladiate portions, and without hydrocladia, thus agreeing with the structure of the branches in the Statoplea generally, which is, in fact, simply a repetition of the primary structure of the proximal part of the stem itself. On a specimen which I examined one branch commenced with an exceedingly short discoid internode, unarmed; the next was longer, cylindrical, with a large sarcotheca in the middle; then followed five longer internodes, each of which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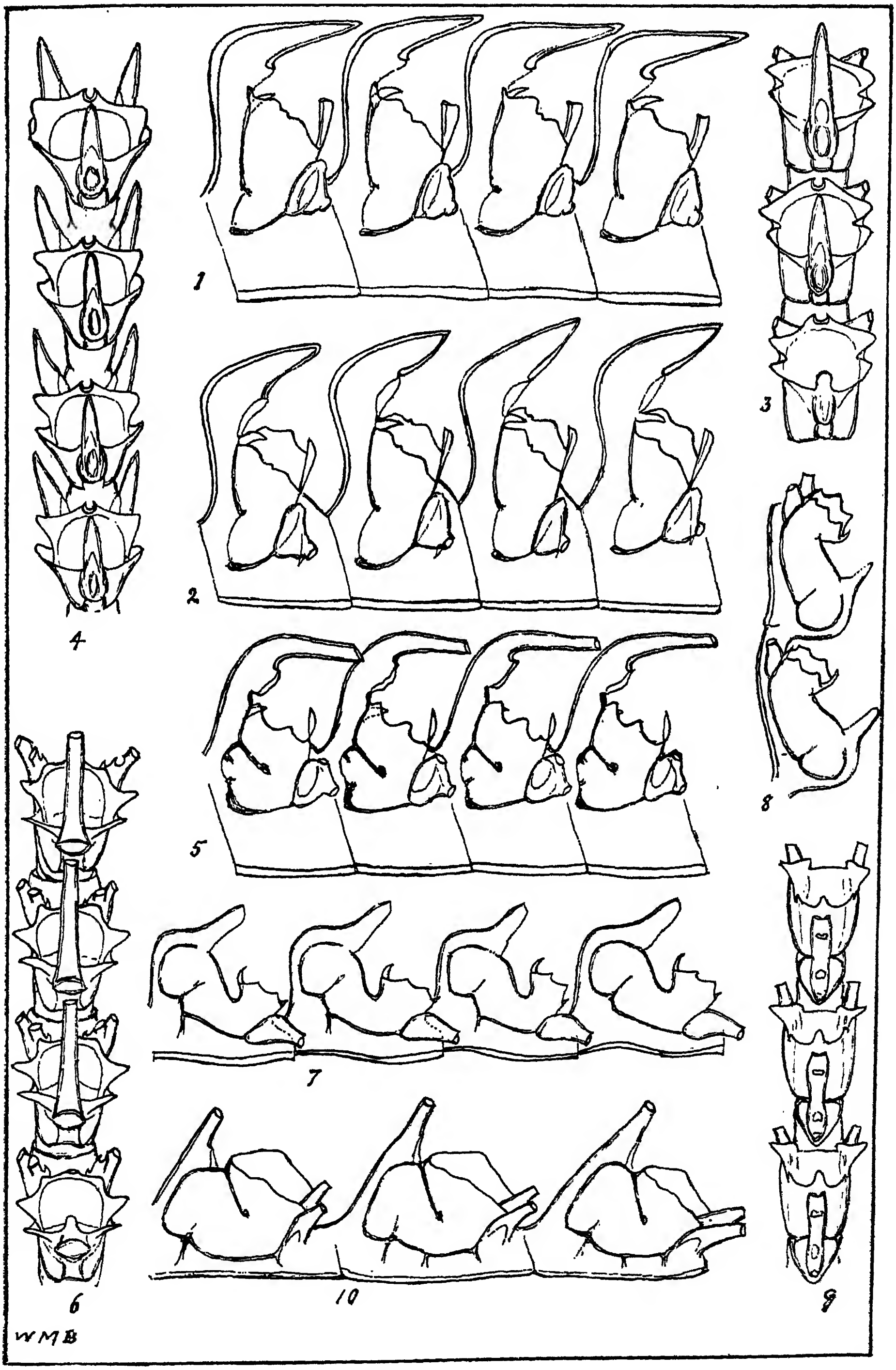

x 80

bore two large sarcothecae abreast; the sixth bore on one side a sarcotheca, and on the other a normal hydrocladium with its two cauline sarcothecae, and the rest were typical. Another branch commenced similarly so far as the first and second internodes were concerned, then followed one internode, with two sarcothecae abreast, the fourth supported one hydrocladium, and the remainder two each. The branches originate at the side of the stem, between two hydrocladia; the order of the hydrocladia is not disarranged, and as the branch is thick it occupies the whole of the space between the two.

EXPLANATION OF PLATES.

Plate XII.

Fig. 1.—*Sertularia muelleri*, n.sp. Front view.
Fig. 2.— „ „ „ Back view.
Figs. 3-5.— „ „ „ Gonothecae.
Fig. 6.—*Sertularia turbinata* (Lamouroux).
Fig. 7.—*Sertularia loculosa* Bale.
Fig. 8.— „ „ „ var.
Fig. 9.—*Sertularia marginata* (Kirchenpauer).
Fig. 10—*Hebella scandens* (Bale), on *Synthecium cylindricum* (Bale).
Fig. 11.—*Hebella cylindrica* (Von Lendenfeld), on *Synthecium alternans* Allman.
(All magnified 40 diameters).

Plate XIII.

Fig. 1.—*Halicornaria arcuata* (Lamouroux).
Fig. 2.— „ „ „ from the same colony.
Fig. 3.— „ „ „ middle of pinna.
Fig. 4.— „ „ „ end of pinna.
Fig. 5.—*Halicornaria ascidioides* Bale.
Fig. 6.— „ „ „ end of pinna.
Fig. 7.—*Aglaophenia brevirostris* (Busk).
Fig. 8.— „ „ „ from same colony.
Fig. 9.— „ „ „
Fig. 10.—*Lytocarpus auritus* (Busk).
(All magnified 80 diameters).

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913].

Art. XI.—*On Eucalyptus polybractea, R. T. Baker.*

By R. T. BAKER, F.L.S.
(Curator, Technological Museum, Sydney).

Communicated by Prof. A. J. Ewart, D.Sc.

In a paper—"A Census of Victorian Eucalyptus"—read by myself before the Australasian Association for the Advancement of Science, in Melbourne, in January, 1913, this Eucalyptus is recorded as Victorian under the above name.

After reading my paper, a specimen was shown to me in the National Herbarium under a label bearing Mueller's writing, *E. fruticetorum*. This has caused me to go once more into the nomeclature of the two species, for I had already gone over the ground before describing the species in 1900.[1]

The name *E. polybractea* was bestowed by myself in 1900.

Since this Eucalyptus was described under the above name it has had various positions given it by other systematic workers on the Eucalyptus.

In 1903, Trans. Roy. Soc. South Australia, Vol. xxvii., pp. 240 and 244, Mr. J. H. Maiden places it along with *E. Woollsiana*, *E. viridis*, and others, as a synonym of *E. odorata*, Behr.

In 1903, Crit. Rev. Gen. Euc., Vol. i., p. 80, the same author places it as a synonym of *E. calycogona*, Turcz., var. *celastroides*, Maiden, and further states:—"I do not think that the original description of *E. fruticetorum*, F. v. M., had been published in Australia until I transcribed it for the Proc. Linn. Soc., N.S.W., 1902.

"I am aware of the confusion that has gathered around E. *fruticetorum*, but Mr. Wilkinson's specimens, named *E. fruticetorum* by Mueller himself, although gathered many years after the original type specimens were collected, answer the description very well. Bentham (B. Fl., 111, 252) states that the West Australian specimens referred to by Mueller in Frag. ii., 57, are referred to *E. loxophleba*, Benth., (*E. foecunda*, Schauer). They are also stated to be the *E. santalifolia*, of Miquel (op. cit. and Mueller in Trans. Vict., Inst., i., 35).

1. Proc. Linn Soc. N.S.W., vol. xxv., 1900, p. 692.

E. fruticetorum, F. v. M., is glaucous, and is so very close to *E. celastroides*, Turcz., that I think its proper place is under *E. calycogona*, Turcz., var. *celastroides*, Maiden.

The *E. gracilis*, F. v. M., figured by Mueller in the Eucalyptographia, is not typical *E. calycogona*, but in part a slightly angled form nearest to *E. fruticetorum*."

Again (loc. cit.), Part iv., issued 1904, he states:—"This is (as regards the Western Australian specimens) identical with *E. loxophleba*, Benth., (B. Fl., iii., 252). I have shown (Part iii., p. 80 of this work) that *E. fruticetorum* is a synonym of *E. calycogona*, Turcz."

In 1904 the same author, Proc. Linn. Soc. N.S.W., p. 761, under *E. odorata*, Behr. gives: "*E. cajuputea*, F. v. M., syn. *E. polybractea*, R.T.B."

Ibid. p. 763.—"Indeed, both it (*E. acacioides*, A. Cunn.) and *E. cajuputea* (*E. polybractea*) are closely related, and both have close affinity to *E. odorata*."

Obid, p. 765.—Under *E. Woollsiana*, R.H.B., states:—"Of the identity of *E. cajuputea* and *E. polybractea*, I have little or no doubt."

Ibid, p. 765.—"For example, Dombey Bay, S.A., specimens show the very great difficulty, perhaps the impossibility, of separating *E. cajuputea* from the Green Mallee (*E. viridis*) and from the Blue Mallee (*E. polybractea*)."

In 1910, by the same author, in his "Critical Revision of the Genus Eucalyptus," vol. ii., p. 40-41, it is placed as a synonym of *E. fruticetorum*, F. v. M., the article finishing up with these words: —"The type specimen (of *E. fruticetorum*) seems to have been lost. I made a personal search in the Melbourne Herbarium for it, with the kind help of Prof. Ewart, and no trace of it can be found at Kew, so Colonel Prain is good enough to tell me. There is no good reason to doubt the correctness of Mueller's determination of this character specimen of his own species."

In the same work, vol. i., p. 79, Mueller's MS. description of *E. fruticetorum* is given, but this is too meagre upon which to place any systematic work.

Now, Bentham, Flora Australiensis iii., p. 252, places this species (*E. fruticetorum*) under *E. loxophleba*, Benth., which Maiden, loc. cit., vol. i., p. 112, places under *E. foecunda*, Sch., and later, p. 119, remarks—"*E. fruticetorum*, F. v. M., Frag. ii., p. 57. This (as regards the Western Australian specimen) is identical with *E. loxophelba*, Benth. I have shown (Part iii., p. 80, of

this work) that *E. fruticetorum* is a synonym of *E. calycogona*, Turcz."

In view of all this revision and counter-revision of nomenclature, concerning this particular Eucalyptus—for first, it was synonymised under *E. odorata* (loc. cit. supra.), then *acacioides* (loc. cit.), then *Woollsiana* (loc. cit.), then *cajuputea* (loc. cit.), next *viridis* (loc. cit.), then *calycogona* (loc. cit.), and, lastly, *fruticetorum* (loc. cit.), it is only natural that one should take a still greater interest in their own species, and this last determination has moved me to go over the ground again.

I might also add that I visited the Melbourne Herbarium several times and examined the specimens there before describing any of my species, and also failed to find a specimen that could be identical with *E. polybractea*. In view, however, of the last that has come to light, I have again gone over Mueller's description of *E. fruticetorum*, Frag. ii., p. 57, and have also again considered all the features in juxta-position with my own original description of *E. polybractea*.

It would go into too much space to particularise each difference, but there are two that stand out very conspicuously, namely :—

E. fruticetorum, F. v. M. Frag. 11, 57.	E. polybractea, R. T. B., Proc. Lin. Soc. N.S.W., 1900, p. 692.
(1). Leaves alternate, moderately petiolate, narrow-falcate or oblong lanceolate; papery or leathery penniveined; shining, marginal vein close to the edge. Leaves 2-4″ long, 4-8‴ wide (these are impossible figures for leaves), tapering into a point, often uncinate.	"leaves alternate," "lanceolate erect," "rarely falcate," oblanceolate;" coriaceous; penniveined; "not shining;" "marginal vein removed from the edge;" "mid-rib on the underside raised, giving the leaf the appearance of an olea leaf," 3-4″ long, under 6 lines wide, uncinate.
(2). Anthers subovate.	Ovate or globular.
Anthers varying from ovate to globose, square and cuneate, more or less bent on itself, dehiscent longitudinally the whole length on both sides.	Anthers globose; dehiscing by terminal pores.

When Baron Von Mueller was describing his *E. fruticetorum*, he could not possibly have had specimens of *E. polybractea* to have so described these two organs, especially the latter, for all his deliniations and description of anthers in the Eucalyptographia are pretty accurate. These two differences alone are sufficient to prove that these two species fall into different groups of Eucalyptus.

One effect of this confounding of nomenclature is that in New South Wales, the oil obtainable from *E. polybractea* being of a high-class character, is in demand on the European and American markets, and when exported from New South Wales is sold under this name, that being the one to which the chemistry is attached in the work on "Eucalypts and Their Essential Oils," published in 1902, and quoted by London buyers.

The same species is now being worked in Victoria in the Inglewood and Bendigo Districts, but the name *E. cajuputea* is attached to the product by at least one manufacturer, a name which belongs really to the South Australian species, *E. odorata*. The Victorian product thus suffers in consequence with those people who know the oil of *E. polybractea* intimately.

Apart then from the systematic side, which, of course, must predominate, commerce would certainly be better served if the original name—*E. polybractea*—is retained for this Mallee, the claims of any other name for the species as shown above being untenable. The name *E. fruticetorum* refers to another species according to Mueller's description (supra). The "Silver leaf" Eucalyptus of Bendigo and Inglewood, Victoria, and the "Blue Mallee" of Wyalong district, New South Wales, are the same species, and its name is *E. polybractea*.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913].

Art. XII.—*Contributions to the Flora of Australia, No. 21.*[1]

The Flora of the Northern Territory (Leguminosae).

BY

ALFRED J. EWART, D.Sc., Ph.D.,

AND

ALEXANDER MORRISON, M.D.

(With Plates XIV., XV.).

[Read 10th July, 1913].

As is well known, the Commonwealth Government, since taking over the Northern Territory, have carried out a policy of energetically investigating the natural resources of this tract of country.

In addition to the expedition by Gilruth and Spencer, the Barclay expedition traversed a large part of the Territory, and Mr. Hill, the botanist attached to the party, made large collections of plants.

Dr. Morrison was appointed to assist in the work of investigating these collections, and the flora of the Territory generally, and the present paper is the first fruits of the work done. It includes the Leguminosae only; the other orders will follow as their examination is completed.

Mr. Maiden has undertaken the investigation of the Myrtaceae and of the Acacias, in which groups his knowledge is unrivalled.

The present paper not only gives much additional information as to the distribution of the plants of this order in the Territory, but also includes descriptions of four new species—Isotropis argentea, Jacksonia anomala, Psoralea luteosa, and Tephrosia pubescens.

Very little is known as yet as to the economic properties of the plants of the Northern Territory, more particularly as regards their fodder value or poisonous properties. Dr. Gilruth obtained data during his first visit of the food value of certain grasses which have since been identified and published in the 19th Contribution to the Flora of Australia.

The Leguminosae include not only many of the most valuable fodder plants, but also many poisonous plants. Few of the

1 No. 20 in Proc. Roy. Soc. Victoria, vol. xxvi. (n.s.), p. 1., 1913.

plants on the present list have been tested as yet from this point of view, but poisonous species are known to occur in the following genera :—Bauhinia has three poisonous species, one of which is a fish poison, and another an anthelminthic, but no data are available for the species of this genus on the present list. *Brachysema undulatum* grows in other parts of Australia, and causes mechanical injury. *Canavalia obtusifolia* causes gastro-enteritis in stock.

Several species of Cassia are considered poisonous, and, according to Greshoff, this also applies to *Cassia Sophora* and *C. Sturtii.* No less than five species of *Crotalaria* are recorded as poisonous, and of these one, *C. Mitchelli,* grows in the Northern Territory. Three species of *Erythrina* and two of *Erythrophlaeum* have been recorded as poisonous, but they do not include any of the species growing in the Territory. The Asiatic *Flemingia congesta* is a taenifuge, but the *F. lineata* of the Territory has not been tested. Many species of *Gastrolobium* are poisonous, but only one incompletely tested species (*G. grandiflorum*) is included in the present list.

Indigofera boviperda, however, has in West Australia been responsible for large losses of stock. The genera *Phaseolus, Psoralea* and *Sesbanea* include poisonous species, but apparently none from the Territory. *Rhynchosia minima* is, however, poisonous according to Greshoff, and the same may be found ultimately to apply to some of the species of *Swainsona* and *Tephrosia.* Several species of the latter genus are well-known fish poisons, and this applies to at least one species from the Territory, namely, *Tephrosia purpurea.* In this direction there will be much work to be done in the future.

ALYSICARPUS LONGIFOLIUS, W. and Arn.

Okey Creek, G. F. Hill (No. 761), 16/2/1912.

ALYSICARPUS RUGOSUS, DC.

Ten miles west of Eva Downs, G. F. Hill (No. 522), 9/8/1911.

ATYLOSIA MARMORATA, Benth.

Maude Creek, Professor Spencer and others, July-August, 1911.

BAUHINIA CUNNINGHAMII, Benth.

S. Lat. 18 deg. 28 min.—Long. 132 deg., G. F. Hill (No. 444), 6/7/1911; Katherine Creek, Professor Spencer and others, July-August, 1911; 40 miles south-east of Newcastle Waters, G. F. Hill (No. 444), 10/8/1911.

BOSSIAEA PHYLLOCLADA, F. v. M.

Sandstone country, near Tanumbirini, G. F. Hill (No. 804), 26/3/1912.

BRACHYSEMA CHAMBERSII, F. v. M.

Forty miles west of Lander Creek, ^{c}iv., G. F. Hill (No. 365), 21/6/1911.

CANAVALIA OBTUSIFOLIA, DC.

North Island, Gulf of Carpentaria, G. F. Hill (No. 628), 20/10/1911.

This plant is poisonous, according to Greshoff, but the poisonous principle is not known.

CASSIA CHATELAINIANA, Gaud.

Seventy miles north of Survey Camp ^{c}iv., G. F. Hill (No. 393), 28/6/1911; S. Lat. 17 deg.—Long. 132 deg., G. F. Hill (No. 455), 7/7/1911.

CASSIA CONCINNA, Benth.

Seventy miles North of Survey Camp, ^{c}iv., G. F. Hill (No. 386a), 28/6/1911; 20 miles south-west of Borroloola, G. F. Hill (No. 574), 7/9/1911; Sandstone country, Borroloola, G. F. Hill (No. 604), 2/10/1911; Lower McArthur River, G. F. Hill (No. 677), 8/11/11.

CASSIA DESOLATA, F. v. M.

Near Haast's Bluff, Macdonnell Ranges, G. F. Hill (No. 208), 26/5/1911.

CASSIA EREMOPHILA, A. Cunn.

Seven miles north of Charlotte Waters, G. F. Hill (No. 17), 23/2/1911; Henbury Station, Finke River, G. F. Hill (No. 43), 9/3/1911; Jay Creek, G. F. Hill (No. 43), 21/3/1911.

CASSIA EREMOPHILA, A. Cunn., var. PLATYPODA.

Charley Creek, Macdonnell Ranges, G. F. Hill (No. 174), 14/5/1911.

CASSIA LEPTOCLADA, Benth.

Sandstone ranges near Western Creek, Borroloola, G. F. Hill (No. 745), 15/2/1912.

CASSIA SOPHORA, L.

Haast's Bluff (3000 ft.), Macdonnell Ranges, G. F. Hill (No. 177), 16/5/1911.

This plant is poisonous, according to Greshoff, but the poisonous principle is not known. The same applies to *Cassia Sturtii.*

CASSIA STURTII, R. Br.

Henbury Station, Finke River, G. F. Hill (No. 36), 7/3/1911; near Haast's Bluff, Macdonnell Ranges, G. F. Hill (No. 205), 26/5/1911; 60 miles north-east of cii., G. F. Hill (No. 282), 7/6/1911.

CASSIA VENUSTA, F. v. M.

cii., G. F. Hill (No. 240a), 3/6/1911; ciii., Lander Creek, G. F. Hill, 10/6/1911; 11 mile Creek, near Katherine, Professor Spencer and others, July-August, 1911; On sandstone ranges, Western Creek, near Borroloola, G. F. Hill (No. 746), 13/2/1912.

CROTALARIA CUNNINGHAMII, R. Br.

Seventy miles north of civ., G. F. Hill (No. 386), 28/6/1911; Borroloola, G. F. Hill (No. 663), 7/11/1911.

CROTALARIA DISSITIFLORA, Benth.

Glabrous form.

Hermansburg, Kinke River, G. F. Hill (No. 54), 11/3/1911.
11/3/1911.

CROTALARIA DISSITIFLORA, Benth.

Hermansburg, Finke River, G. F. Hill (No. 54), 11/3/1911.

CROTALARIA LINIFOLIA, Linn. f.

Borroloola, G. F. Hill (No. 615), 9/10/1911; Lower McArthur River, G. F. Hill (No. 676), 8/11/1911.

CROTALARIA LINIFOLIA, Linn. f.

Elongated variety.

Orkey Creek, G. F. Hill (No. 761), 16/2/1912.

CROTALARIA MITCHELLI, Benth.

Twelve miles north-west of ciii. (Long. 132½—Lat. 21¾ S.), G. F. Hill (No. 326), 12/6/1911.

This plant is poisonous, according to Greshoff and to Maiden, but the poisonous principle is unknown.

CROTALARIA RETUSA, L.

Edith Creek, Professor Spencer and others, July-August, 1911; Lower McArthur River, G. F. Hill (No. 681), 8/11/1911.

CROTALARIA TRIFOLIASTRUM, Willd.

Haast's Bluff (4000 ft.), Macdonnell Ranges, G. F. Hill (No. 191), 18/5/1911.

CROTALARIA TRIFOLIASTRUM, Willd.

Lat. 19 deg. S., Long. 132 deg., G. F. Hill (No. 434), 4/7/1911. Form with leaflets 2 mm. broad.

DESMODIUM MUELLERI, Benth.

Near Western Creek, G. F. Hill (No. 755), 15/2/1912; Western Creek, G. F. Hill (No. 757), 15/2/1912.

ERYTHRINA VESPERTILIO, Benth.

About 30 miles north-west of Twitchera Gap, Macdonnell Ranges, G. F. Hill (No. 165), 10/5/1911; Borroloola, G. F. Hill (No. 665a), 8/11/1911.

ERYTHROPHLAEUM LABOUCHERII, F. v. M.

Newcastle Waters, G. F. Hill (No. 473), 7/7/1911.

FLEMINGIA LINEATA, Roxb.

Edith Creek, Professor Spencer and others, July-August, 1911.

GASTROLOBIUM GRANDIFLORUM. F. v. M.

Seventy miles north civ. on Lander Creek, G. F. Hill (No. 382), 28/6/1911.

This is poisonous, according to Greshoff, and acts as an inebriant. The poisonous principle is not known with certainty, but may be a readily decomposing alkaloid.

INDIGOFERA BOVIPERDA, Morrison.

(Journ. of Botany, l., 166, May, 1912.)

To the description of fruiting specimens in the place above quoted may be added the following notes of flowers on specimens from the Northern Territory:—

longer than tube; bracts lanceolate-subulate, 2-3 mm., deciduous

Calyx about 3 mm., tube broad, lobes narrow lanceolate, rather before flower opens; petals reddish purple, standard broadly ovate on a short claw, 6 x 4 mm., villous externally, keel as long, slightly incurved, obtuse, tomentose on lower margin, both minutely apiculate, wings shorter, 5 mm., narrow oblong; anthers acutely apiculate, 0.6 mm. long, ovary villous, style incurved, stigma small.

Lander Creek, N.T., about 21 deg. S. Lat., and 132 deg. E. Long., G. F. Hill, No. 374, 25/6/1911; also Ashburton River, N.W. Australia, Stuart Carey, 1883.

The plant poisoned 120 cattle in one night at the Ashburton River in 1905, and some settlers recognised it as a reputed poison plant seen by them also in the Kimberley District, further north. The area of its distribution is, therefore, very extensive.

INDIGOFERA BREVIDENS, Benth.

G. F. Hill, 1911.

INDIGOFERA ENNEAPHYLLA, L.

Sixty miles north-east of cii., G. F. Hill (Nos. 285 and 287), 7/6/1911.

INDIGOFERA HAPLOPHYLLA, F. v. M.

Sandstone ranges, near Western Creek, G. F. Hill (No. 772), 16/2/1912.

INDIGOFERA LINIFOLIA, Retz.

Hermansburg, Finke River, G. F. Hill, No. 83, 13/3/1911.

ISOTROPIS ARGENTEA, Ewart and Morrison.

Flowers in axillary racemes, petals yellow, of about equal length, keel beaked, pod oblong, obtuse, seeds numerous, smooth.

A slender, few-branched undershrub, 1½ feet high, the whole plant clothed with an indumentum of appressed shining hairs. Leaves unifoliolate, articulate on a very short petiole, narrow linear, flat but closely induplicate, subacute and recurved at distal end, in length up to 5 cm. x 0.3 cm. broad, the stiff silvery hairs more dense on under surface. Stipules subulate and short.

Racemes short, axillary or terminal, flowers few or solitary, peduncles 6-8 mm., with a pair of narrow lanceolate bracts at articulation near or above middle, and similar but smaller bracteoles close to calyx, which is about 7 mm. long, two lipped, lobes at least twice as long as tube, lanceolate, the upper pair united higher up, forming a broad lip, the lower lobes curving over the prominent keel. Petals yellow, about as long as calyx, standard on a very short, broad claw, ovate, obtuse, wings slightly shorter, oblong, membranous near base, keel as long as standard with a very slender claw, sharply incurved and broad and membranous below the straight beak. Pod sessile, densely pubescent with stiff erect hairs brown on young pod at first, but yellowish on mature pod, which is turgid, oblong, obtuse with a minute recurved blunt point, 2.1

cm. long x 0.6 cm. thick, the pedicel enlarged under it; funicles short, seeds about 26 in pod, subreniform, astrophiolate, flattened and smooth.

Ten miles west of Eva Downs, G. F. Hill, No. 524a. 19/8/1911.

The obtuse pod of this plant, as well as the large beaked keel, distinguished it from the other species of Isotropis. In I. Wheeleri, F.v.M., the seeds are reniform, with a strongly-marked network of raised lines on the surface, and the pubescence is of a different character, its racemes also are terminal, and its pod smaller and acute, while the leaves are tubular rather than terete and channelled as described by Bentham. I. Winneskii, F.v.M., has smaller seeds, symmetrically reniform, and rugose over a broad band round the outer margin, the funicle remaining attached in the narrow sinus.

JACKSONIA ANOMALA, Ewart and Morrison, n. sp.

Upper lobes of calyx shorter than lower, connate to top. petals somewhat shorter than calyx, standard small, shorter than the other petals, pod subglobose with two seeds. Flowers small situated on base of dichotomous, striate, leafless stems, with broad scarious bracts and bracteoles.

A small undershrub reaching one foot in height, with numerous stems repeatedly forked from base; branches flattened angular, striate, not pungent, at first thinly pubescent, 1.5 mm. broad; leaves represented by small brown lanceolate scales at nodes. Flowers very shortly pedicellate on short dense nearly sessile racemes clustered on basal rounded portions of branches, each subtended by a suborbicular brown villous bract, with a pair of oblong ovate mucronate bracteoles at base of calyx, in both cases ·5 mm. in length, and persisting. Calyx densely silky villous, cleft to near base, lower lobes 9 mm. oblong-linear and acuminate, connate to top and forming a broad ovate lip 7-8 mm. long, with a subulate bifid tip. Petals and pod firmly clasped by calyx, standard broadly ovate, on a very short broad claw, about 5 mm. in length, and fitting under the concave upper lip of the calyx, wings on a very slender claw, narrow oblong, of about the same length as keel, but with a transverse fold near top, keel nearly 8 mm. long, ovate lanceolate. Pod ovoid or subglobose, sessile, villous, 1 cm. long, including the straight and tapering acuminate beak, which is nearly as long as the pod itself, and exceeds the calyx; seeds two, approximately reniform, smooth, brown, 2 mm. in length.

Lat. 18 deg. 27 min. S. Long. c 132 deg. E. G. F. Hill, No. 499. 6/7/1911.

This plant shows affinities to some of the Brachysemas, particularly the xerophytic species of the section Leptosema, in the leafless condition, radical inflorescence, broad bracteoles (as in B. bracteolosum), connate upper calyx lobes, and small ovate standard; but it differs in the small number of seeds in the pod, and in the size and colour of the flowers. Compared with Jacksonias, on the other hand, it agrees in having small flowers, with the upper calyx lobes shorter than the lower, petals yellow, nearly equal in length, and shorter than the calyx. The seeds in the pod are only two, which is the usual number in Jacksonia, and if we consider that the leafless condition is normal in that genus, while exceptional in Brachysema, there need be no hesitation in deciding its generic position.

There is seen in this species a considerable resemblance to some of the smaller forms of the Scoparia section found in extra-tropical South-west Australia, and its mature calyx even shows the angular character noted in the buds of J. angulata and others.

JACKSONIA DILATATA, Benth.

Edith Creek, Professor Spencer and others, July-August, 1911; Bacon Swamp, Professor Spencer and others, July-August, 1911; Sandstone ranger, Borroloola, G. F. Hill (No. 600), 2/10/1911.

JACKSONIA ODONTOCLADA, F. v. M.

Hell Gate, Roper River, Professor Spencer and others, July-August, 1911.

JACKSONIA RAMOSISSIMA, Benth.

Twenty miles south-west of Borroloola, G. F. Hill (No. 564), 7/9/1911.

LOTUS AUSTRALIS, Andr.

^{c}iii., Lander Creek, G. F. Hill (No. 316), 10/6/1911.

Classed as a poison plant by Greshoff, Smith and Maiden. but no poisonous principle has been extracted, and the evidence as to its poisonous properties is not satisfactory.

MIRBELIA OXYCLADA, F. v. M.

On sandhills, 70 miles north of Survey Camp ^{c}iii., G. F. Hill (No. 394), 25/6/1911; 110 miles north of Survey Camp, ^{c}iv., G. F. Hill (No. 408), 1/7/1911.

PETALOSTYLES LABICHEOIDES, R. Br., var. CASSOIDES, Benth.

Jay George, Macdonnell Ranges, G. F. Hill (No. 133), 4/5/1911; 40 miles N.N.W of Meyer's Hut, G. F. Hill (No. 233), 2/6/1911.

PETALOSTYLES LABICHEOIDES, R. Br., var. microphylla, n. var.

Forty miles west of Lander's Creek, civ., G. F. Hill (No. 364), 23/6/1911. The stems and leaf-rhachis of this variety are stouter, more rigid, and almost spinescent, terete and covered by a dense hoary coating of hairs. The leaflets reach to 41 in number, and are broadly obovate and retuse or even obcordate, thinly pubescent on lower surface and glabrous above, measuring 2-4 mm. in length by less than 3 mm. in breadth. The sepals are thinly pubescent, and are longer and broader (13 by 3 mm. max.) than those of No. 133, var. cassioides, in which, however, the petals are larger, and the leaflets reach 45 in number.

In the form No. 233, which is almost glabrous, the leaflets are mostly 5-6 mm. long, with the terminal one 8-9 mm. Numerous intermediate forms connect the small-leaved varieties with the fully-developed type.

The var. cassioides described by Bentham (from Sturt Creek and Gulf of Carpentaria) is represented in the Melbourne Herbarium by specimens from Sturt Creek and Nicholson River, both collected by F.v.M. in 1856, but neither has the varietal name added on the labels. On the other hand a specimen of var. microphylla (from Mt. Churchman, W.A., Young) is labelled by the Baron, evidently in error, "var. cassioides," but in it there are between 50 and 60 leaflets, measuring only 2-3 mm. in length, hirsute, and with a recurved blunt point. Another specimen, collected by Giles shows the rigid and almost spinescent character, while two specimens from the upper Ashburton River, W.A. (Cuthbertson, 1888) indicate, the one, a development approaching the typical, and the other a scrubby form similar to v. microphylla in the size of the leaf. The leaf development may be taken to indicate the nature of the water supply, the small-leaved forms being found in arid surroundings; although the bed of a river where moisture is retained in the mud and gravel, produces in the driest season the fully-developed form in flower, while beyond the overhanging banks almost all else is desiccated and dormant.

PHASEOLUS MUNGO, L.

Okey Creek, G. F. Hill (No. 765), 16/2/1912.

PITHECOLOBIUM MONILIFERUM, Benth.

Borroloola, G. F. Hill (No. 582), 12/9/1911; McArthur River, G. F. Hill (No. 582).

PSORALEA BADOCANA, Benth.

Maude Creek, Professor Spencer and others, July-August, 1911; 11 Mile Creek (near Katharine), Professor Spencer and others, July-August, 1911.

PSORALEA CINEREA, Lindl.

Lake Woods, G. F. Hill (No. 486), 2/8/1911.

PSORALEA LEUCANTHA, F. v. M.

Survey Route, Lat. 19 deg. 16 min. S., G. F. Hill (No. 429), 4/7/1911.

PSORALEA LUTEOSA, Ewart and Morrison, n. sp.

Lowermost calyx lobe slightly longer than rest, which are equal; petals green, glabrous, standard and keel equal, wings slightly shorter; style glabrous, terete; pod ovoid, indehiscent, two-seeded. Plant glandular, with trifoliolate digitate leaves and large scarious stipules.

Leaves on striate angular petioles of about 2 cm., trifoliolate, digitate, leaflets lanceolate, entire, obtuse or subacute, the terminal one larger (4.3 x 3.5 cm.), thinly woolly tomentose on both sides, veins prominent on under side and ending at margin, sprinkled with minute black glands. Stipules 7 mm. in length, lanceolate, striate, scarious.

Flowers in nearly sessile racemes, which spring from leafless base of branches or from upper axils, the longest 12 cm.; bracts linear-lanceolate, striate, scarious, 3 mm. long, completely covering buds in dense young racemes, deciduous like the stipules, pedicels single or in pairs, 2-4 mm. long, at length distant. Calyx about 6 mm., glandular, silky villous, lobes linear-lanceolate acuminate, three times as long as the campanulate tube, the lowermost 1 mm. longer than the others, which are equal, the upper pair shortly united at base. Petals shortly exceeding calyx, yellowish green, standard obovate or suborbicular, somewhat reflexed, with a pair of small auricles above a tapering claw, 6-7 mm. long, x 4 mm. broad; keel quite as long, incurved, obtuse, glabrous like the standard, wings a little shorter, narrow, falcate, adhering to keel at base, claws of both narrow linear; ovary sessile, villous, style incurved, glabrous, terete; pod indehiscent, oblong-ovoid, about half as long as calyx, villous, obtuse, with a horn-like incurved point, seeds two, astrophiolate, oblong, brown, 1 mm. in length, dorsal side flat, with a narrow rim enclosing a long pit.

Northern Territory, north of Lat. 15 deg. S., W. S. Campbell, September, 1911.

A small glandular undershrub, with its branches rising erect from horizontal rhizomes or branches to a height of 14 cm. over all. In Tephrosia the glandular character is not observed, the leaves are generally pinnate, the standard tomentose, and style flattened; the pod also is seldom ovate, but flat and dehiscent, and contains usually more than two seeds. While this number of seeds is an exceptional minimum in Tephrosia, it is rare to find more than one in Psoralea. Although there are many differences from either genus in the details of structure of the flowers, there are more points of resemblance to Psoralea than to Tephrosia, and the glandular character, digitate leaves, and structure of the pod point to the former. If the digitate leaves with three entire leaflets be taken as a guide to its position in the genus, it would be placed in the small group represented by P. adscendens, but its other characters differ widely. The yellowish-green colour of the flowers is not recorded in Australian species of either Psoralea or Tephrosia. The species is apparently related to F. v. Mueller's P. Schultzii, of which only a few (purple) flowers and some leaf fragments exist.

PSORALEA PATENS, Lindl.

Abraham's Lagoon, Professor Spencer and others, July-August, 1911.

PSORALEA PUSTULATA, F. v. M.

Newcastle Waters, G. F. Hill (No. 474), 17/7/1911.

PTYCHOSEMA TRIFOLIOLATUM, F. v. M.

Lander Creek, ciii., G. F. Hill (No. 306), 10/6/1911.

RHYNCHOSIA MINIMA, DC.

Lower McArthur River, G. F. Hill (No. 675), 8/11/1911.

SESBANIA ACULEATA, Pers.

Crescent Lagoon, Professor Spencer and others, July-August, 1911; McArthur River, G. F. Hill (No. 672), 8/11/1911; Hodson Downs, G. F. Hill (No. 827), 5/4/1912.

SESBANIA GRANDIFLORA, Pers.

North of 15 deg., W. S. Campbell, 5/9/1911.

SWAINSONA BURKEI, F. v. M.

Thirty-eight miles north-west of ᶜiv., Lander Creek, G. F. Hill (No. 378), 24/6/1911.

SWAINSONA OROBOIDES, F. v. M.

Sixty miles north-east of ᶜii., G. F. Hill (Nos. 284 and 286a), 7/6/1911.

SWAINSONA sp.

Ten miles west of Eva Downs, G. F. Hill (No. 521), 19/8/1911.

TEMPLETONIA HOOKERI, Benth.

(NEMATOPHYLLUM HOOKERI, F. v. M.)

South of Newcastle Waters, G. F. Hill (No. 481), 12/7/1911; track to Maude Creek, Professor Spencer and others, July-August, 1911.

TEPHROSIA FILIPES, Benth.

Haast's Bluff (4000 ft.), G. F. Hill (No. 188), 17/5/1911.

TEPHROSIA FLAMMEA, F. v. M.

North Island, Gulf of Carpentaria (sandstone ranges), G. F. Hill (No. 633), 20/10/1911; Borroloola, G. F. Hill (No. 657), 7/11/1911; sandstone ranges, near Western Creek, G. F. Hill (No. 777), 16/2/1912.

TEPHROSIA PHAEOSPERMA, F. v. M.

North Island, Gulf of Carpentaria, G. F. Hill (No. 624), 20/10/1911.

TEPHROSIA PUBESCENS, Ewart and Morrison, n. sp.

Flowers in pedunculate axillary racemes, calyx lobes and tube of about equal length, standard half as long again as calyx, keel as long, incurved and very shortly beaked; leaves trifoliolate, with prominent veins anastomosing within the margin.

Leaves trifoliolate on petioles of 2 cm. or less, leaflets ovate or obovate, petiolulate, terminal one 3 cm., and larger than the lower pair, primary veins anastomosing within the margin, very prominent, as are also the intervening reticulations, smoother and greenish on upper surface. Stipules small, lanceolate.

Flowers in short racemes of 1.5 cm. pedunculate in uppermost axils, peduncles much longer than leaves, rusty pubescent like the stem, pedicels about as long as calyx; calyx tube narrow companulate 0.5 cm., lobes lanceolate acute, upper pair about as long as tube, and united to near the top, lowermost 0.6 cm.

Standard broadly obovate-cuneate, very obtuse, yellowish, with purple veins, 1.5 cm. long x 0.5 cm. broad at top, keel about same length and breadth, incurved, with a very short obtuse beak, wings shorter and narrow. Upper stamen geniculate, not hairy. Ovary villous. Pod not seen.

Top Spring, G. F. Hill, No. 535, 31/8/1911.

An undershrub, with somewhat stout unbranched stems, clothed like the inflorescence and petioles, with a rusty indumentum, the leaflets greenish grey, with a dense and close pubescence and very prominent veins and reticulations as in T. coriacea and flammea. In shape and indumentum, however, the leaves differ, as well as in the long and stoutish peduncles bearing cluster-like racemes at the top.

TEPHROSIA PURPUREA, Pers.

Sandstone ridges, North Island, Gulf of Carpentaria, G. F. Hill (No. 630), 20/10/1911; Borroloola, G. F. Hill (661), 7/11/1911; sandstone ranges, near Western Creek, Borroloola, G. F. Hill (No. 745a), 15/2/1912.

This plant is well known as a fish poison, and if eaten might also be poisonous to stock.

TEPHROSIA UNIOVÚLATA, F. v. M.

Twenty-eight miles south-west of Newcastle Waters, G. F. Hill (No. 499), 8/7/1911.

URARIA CYLINDRACEA, Benth.

Five mile bar, McArthur River, G. F. Hill (No. 734), 6/2/1912.

ZORNIA DIPHYLLA, Pers.

Black Rocks, McArthur River, G. F. Hill (No. 644), 22/10/1911, sandstone range, Top Spring, Kilgour River, G. F. Hill (No. 553), 1/9/1911.

EXPLANATION OF PLATES.

PLATE XIV.

Fig. 1.—Indigofera boviperda, Morrison.
Fig. 2.—Jacksonia anomala, n.sp.

PLATE XV.

Fig. 1.—Tephrosia pubescens, n.sp.
Fig. 2.—Psoralea lutessa, n.sp.
Fig. 3.—Isotropis argentea, n.sp.

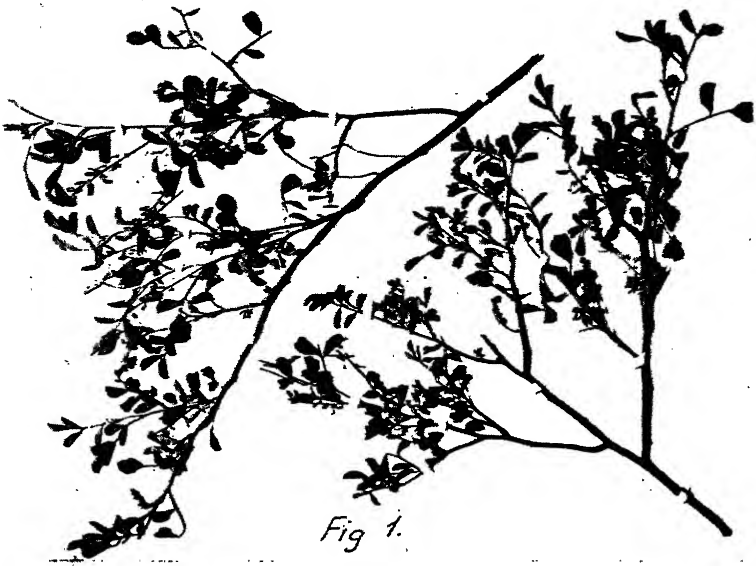

Fig 1.

Fig 2.

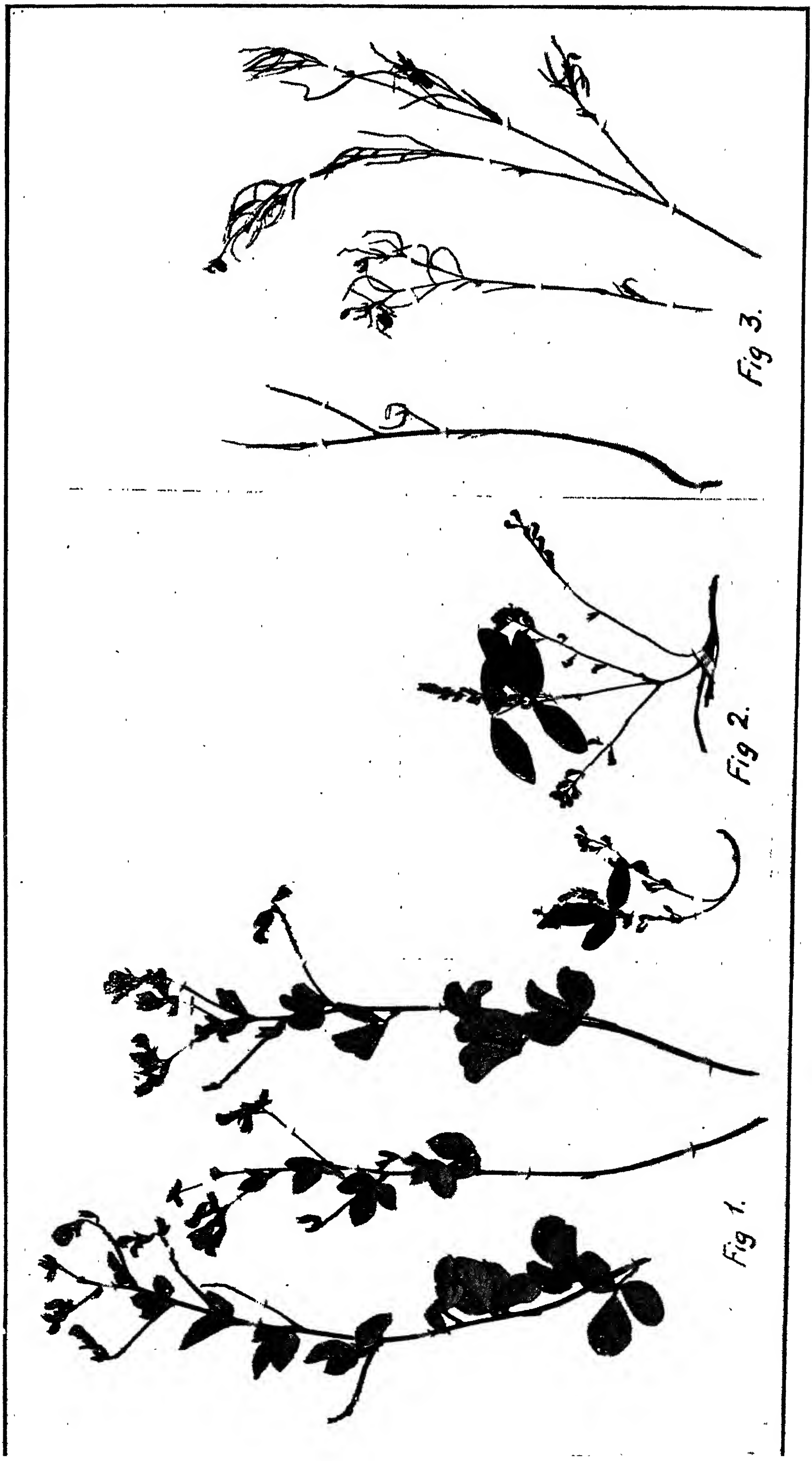
Fig 1.
Fig 2.
Fig 3.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913.]

Art. XIII.—*Description of New and Rare Fossils obtained by Deep Boring in the Mallee.*

Part I.—Plantae; and Rhizopoda to Brachiopoda.

By FREDERICK CHAPMAN, A.L.S., F.R.M.S., &c.
(Palaeontologist to the National Museum, Melbourne).

(With Plates XVI.-XIX).

[Read 10th July, 1913].

Introductory Note.

In this and the two succeeding parts are embodied the palaeontological results of a somewhat exhaustive study of the material brought up by borings in the Mallee near Ouyen, numbered 1-11. The actual boring was carried out between August, 1908, and August, 1909. The borings are all in the County of Weeah. and commence at about six miles east of the South Australian boundary, and fifty miles north of the 36th parallel at Pinaroo. The bores are situated at distances of two to four miles apart.

The second part of this report will comprise the mollusca, written in conjunction with Mr. C. J. Gabriel, and the third part, by myself, will comprise the groups of the Ostracoda and Fishes.

The report containing the general results will subsequently appear in the publications of the Geological Survey of Victoria.

Plantae.

Boring fungi, indet.

In one instance, Bore 9, 315-325 feet, the remains of a boring fungus are seen in the outer, aragonitic layer of a (?) *Dosinea* valve. The thallus forms stellate groups, measuring about 3 mm. across. The tubes average about .115 mm. in diameter. A microscope section did not reveal any recognisable structure.

In Bore 1, 154-190 feet, the rolled shells of mollusca are freely riddled with a similar form of perforating plant, but showing less regularity in outline.

Genus LITHOTHAMNION, Philippi, 1837, Foslie, emend. 1900.

LITHOTHAMNION RAMOSISSIMUM, Reuss sp. (Plate XVI., Figs. 1*a-c*, 2, 3).

Nullipora ramosissima, Reuss, 1848, Haidinger's Naturw. Abhandl., vol. ii., pt. ii., p. 29, pl. iii., figs. 10, 11. Unger, 1857, Denkschr. K. Akad. Wiss. Wien, vol. xiv., pp. 23, 38, pl. v., figs. 18-22.

Lithothamnium ramosissimum, Reuss sp., Gümbel, 1871, Abhandl. k. bayer. Akad. Wiss., vol. xi., pt. i., p. 34, pl. i., figs. 1*a-d*.

Cumulipora rosenbergi, Martin, 1881, Samml. Reichsmus. Leiden, vol. i., pt. i., pp. 12-14, 64, pl. iii., figs. 6, 7.

Lithothamnium rosenbergi, Martin sp., Martin, 1881, Ibid. vol. i., pt. ii., pp. 70, 79. Ibid, 1882, vol. i., pt. iii. pp. 153, 155.

L. ramosissimum, Rss. sp. Rothpletz, 1891, Zeitschr. deutsch. geol. Gesellsch., vol. xliii., p. 320. Nishiwada, 1894, Journ. Coll. Sci. Imp. Univ. Tokyo, vol. vii., pt. iii., p. 233, pl. xxix., figs. 1-3.

L. (Cumulipora) rosenbergi, Martin, Newton and Holland, 1900, Journ. Geol. Soc. Tokyo, vol. vii., No. 81, p. 1.

L. rosenbergi, Martin, sp. Yoshiwara, 1900, Journ. Geol. Soc. Tokyo, vol. vii., No. 81, p. 22.

Lithothamnion ramosissimum, Reuss sp., Foslie, 1900, "Revised Systematical Survey of the Melobesidae," Kongl. Norske Vidensk. Selsk. Skr. No. 5, p. 12 (No. 14).

Lithothamnium ramosissimum, Rss. sp., Newton and Holland, 1902, Journ. Coll. Sci. Imp. Univ. Tokyo, vol. xvii., Art. 6, p. 17, pl. i., fig. 8.

Observations.—From Jurassic times the branching Lithothamnia have played an important rôle in the formation of limestones, especially those associated with reef-making corals. The distinguishing characters of this plant, apart from the fruiting organs, are not easily defined, the form of the thallus being very variable. Solms Laubach[1] cuts the gordian knot in that he says, "We shall do well to follow Unger in this matter, and put them all together as *Lithothamnium ramosissimum*."

My own conviction is, that when the cell structure is well preserved, and the mode of frutification shown, the fossil specimens are as good as living examples for diagnostic purposes. It has

1. Fossil Botany, Oxford, 1891. English translation by H. E. F. Garnsey, p. 45.

hitherto been the usage amongst palaeobotanists[1] to separate the encrusting forms of *Lithothamnion* as *Lithophyllum;* but as Foslie (whose untimely death we have recently had to deplore), showed,[2] that, having regard to the reproductive organs of the plants, that method was based on insufficient ground. From a study of the recent forms of the group, Foslie included nearly all the species of *Lithophyllum* in *Lithothamnion*, the latter genus being defined by the downward growth of the conceptacles into the frond (subgen. *Eulithothamnion*, sect. Innatae) or by their superficial character (sect. Evanidae). The present species falls into the first section of the subgenus mentioned.

The conceptacles with tetraspores can be found in the fossil examples by slicing, almost as easily as in the recent forms. In these specimens from the polyzoal rock of the Mallee bores, it is found that the conceptacles are immersed in the thallus, the surface of which is sometimes overarched above the conceptacles. The conceptacles here examined were slightly broken during slicing, so that the true outline of the cavity was not seen. It has already been stated[3] that the tetraspores "could be but imperfectly fossilised," since they contain very little carbonate of lime. It is, therefore, particularly interesting to note that the tetraspores are here present, and preserved as glauconite pseudomorphs of a pale green tint. The example figured shows two of the tetraspores clinging to the inner wall of one of the conceptacles, whilst another is seen in an adjoining cavity. These tetraspores are ovoid, and pointed at the base of attachment. The pseudomorphic change into glauconite shown by these fossil bodies is more easily understood when we compare them with the sarcode bodies of Foraminifera replaced by the same substance, for I am inclined to believe that the glauconitisation of foraminifera takes place as a reactionary product of the protoplasm, and not as a mere infilling of the dead shells, in which case we should most probably get a concentric structure developed in the glauconite. This assumption can, of course, only be proved by detailed observation and chemical experiment.

In *Lithothamnion nummuliticum*[4] the cell structure is quadrate and smaller than in *L. ramosissimum*, to which we refer nearly all the present examples. The specific standing of the latter is further

1. Seward. Fossil Plants, vol. i., Cambridge, 1898, p 186.
2. Foslie. Op. supra cit., p. 5, et seq.
3. See Waters, A.W., on "Fossil Lithothamnia". Mem. Lit. and Phil. Soc. Manchester, vol. v., 1874, p. 248. This paper gives a useful resumé of the occurrences of the fossil Lithothamnia as rock-forming agents (pp. 244-250).
4. *Lithothamnium nummuliticum*, Gümbel. Abhandl. k. bayer, Ak. Wiss., vol. xi. (1), 1871 p. 37, pl. i, fig. 2*a-e*.

supported by the external form of the specimens, which is in general agreement with other Miocene examples, of which some of the synonymy is given above.

Rothpletz[1] gives the cell measurement of his examples of *L. ramosissimum* as $20 \times 14\text{-}16\mu$, whilst the specimens from the Mallee vary from about that proportion to $30 \times 17\mu$. This amount of variation in the cell measurement can be found in a single branch in our specimens, so that the dimensional character must be taken with other factors, viz., the habit of the branches and the form and position on the thallus of the conceptacles, whether immersed, sub-immersed, or prominent.

There is little doubt that the encrusting layers of calcareous algae found on some of the pebbles in the present borings are merely the early stage of the above, or a closely allied species, as the cells agree in form, and spread out fan-wise over the surface as in the basal parts of a branching specimen.

The above species is a peculiarly Miocene form. It constitutes the bulk of the Leithakalk (Tortonian) of the Vienna Basin. In Eastern Asia it accompanies Miocene forms of *Lepidocyclina*, such as have been recorded from Japan, Timor, New Guinea, Amboina, Batu Island, Formosa and Riu Kiu.

Distribution.—Bore 3, 201-220 feet and 226 feet. Bore 4, 163-170 feet. Bore 5, 163-175 feet (figd.), and 175-189 feet. Bore 10, 310-320 feet. Bore 11, 438-440 feet, and 457-458 feet.

[In working out the above details I have been assisted with literature, and specimens of recent material, through the kindness of Mr. C. J. Gabriel.]

Lithothmanion aff. lichenoides, Ellis and Solander.

Millepora lichenoides, Ellis and Solander, 1786, Nat. Hist. Zoophytes, p. 131, pl. xxiii., fig. 9.

Lithothamnion lichenoides, Ell. and Sol. sp., Foslie, 1900, Kongl. Norske Vidensk. Selsk. Skr. (No. 5), p. 14, No. 55.

In this form the branches are flattened or frondose, with the conceptacles superficial.

Distribution.—Bore 11, 457-458 feet.

Lithothamnion spp, indet.

Specimen *a.*—Bore No. 3, about 226 feet, yielded two pebbles partly formed of an encrusting *Lithothamnion*.

1. Op. cit., p. 303.

Specimen *b*.—This is an encrusting thallus, very thin, one cell layer in thickness, spread over the surface of a phosphatic pebble from Bore 3, 206 feet. The elongate-rectangular cells are like those of *Lithothamnion ramosissimum*, but much larger. They spread far-wise over the surface, and the limiting plane of each successive growth is undulate or convex. In some respects it is allied to *Lithothamnion lichenoides*, Ellis and Sol. sp., which Foslie places in his second section (Evanidae) of the subgenus *Eulithothamnion*. The question here arises whether a form like *L. ramosissimum*, when attached to a rolling pebble, does not conform to its surroundings and show a varietal mutation on account of the abnormal conditions of its existence.

Genus LITHOPHYLLUM, Philippi.

(?) LITHOPHYLLUM sp.

This is a comparatively large fragment, subcylindrical, measuring 11 x 5.5 mm. It cannot be referred to a branchlet of *L. ramosissimum*, since the successive concentric layers of the growing thallus are separated by narrow spaces, which show it to be persistently encrusting; and what is more important, there are circular depressions over the surface on the summits of low monticules, pointing to superficial conceptacles.

Bore 1, 212-215 feet.

Animalia.

FORAMINIFERA.

Fam. MILIOLIDAE.

Genus TRILLINA, Schlumberger.

TRILLINA HOWCHINI, Schlumberger. (Plate XVI., Fig. 4).

Trillina howchini, Schlumberger, 1893, Bull. Soc. Géol. France, ser. 3, vol. xxi., p. 119, woodcut fig. 1, and pl. iii., fig. 6. Chapman, 1908, Proc. Linn. Soc. New South Wales, vol. xxxii., p. 753, pl. xxxix., figs. 7-9.

Observations.—This remarkable and easily indentifiable species was figured and described by M. Schlumberger from the lower beds at Muddy Creek, near Hamilton, where the Rev. W. Howchin found it to be moderately common. It also occurs in Miocene strata in the New Hebrides. It was only occasionally found in the present bores, in strata identified as Janjukian by the general characters of its facies. It here evidently persists into a higher horizon than that

represented by the Muddy Creek lower beds (Balcombian), for it is associated in Bore 4 with some undoubted Kalimnan forms, as *Bathyactis beaumariensis*, although the remainder of the fauna at 163-170 feet is essentially Janjukian.

The example figured above resembles *M. vulgaris* in contour, whilst others are nearer *M. tricarinata* in outline, the species being much subject to variation.

Distribution.—Bore 2, 211-240 feet, very common. Bore 3, about 260 feet. Bore 4, 163-170 feet. Bore 11, 267-270 feet.

Genus ORBITOLITES.

Orbitolites complanatus, Lamarck.

Orbitolites complanatus, Lamarck, 1801, Syst. Anim. sans Vert., p. 376. Carpenter, 1856, Phil. Trans., p. 224, pls. iv-ix.

Observations.—As a fossil this species has been previously recorded from Victoria by Mr. Howchin, as rare at Muddy Creek (lower beds; Balcombian); it has also occurred in the Govt. well-boring in the Murray Flats, South Australia. *O. complanata*, as remarked by Mr. Howchin, was living on the South Australian coast to within Pleistocene times, but is now extinct in that area.

Distribution.—In the present borings this species is of common occurrence, and seems mainly confined to the greensand and phosphatic deposits of the Janjukian and Kalimnan series.

Fam. LITUOLIDAE.

Genus AMMODISCUS, Reuss.

Ammodiscus ovalis, sp. nov. (Plate XVI., Figs. 5*a*, *b*).

(?) *Ammodiscus* sp., Chapman and Howchin, 1905, Mem. Geol. Surv. New South Wales, Palaeont. No. 4. Foram. Permo-Carb. Limestones of New South Wales, p. 11, pl. i., figs. 12*a-c*.

Description.—Test composed of fine arenaceous mud, consisting of a depressed, sparsely-coiled shell, elongated in one direction to form an irregular oval. Thinner in the centre than at the periphery.

Dimensions.—Longer diameter, .692 mm.; shorter diameter, 384 mm. Thickness, cir., .077 mm.

Observations.—The examples doubtfully referred to the genus *Ammodiscus* by Mr. Howchin and myself, from the Carbopermian

of New South Wales, is of the same type of shell as the above, and may be regarded as a depauperated and sparsely coiled form of the *Ammodiscus* type. The nearest allied examples to the above are the *Ammodiscus robertsoni*, Brady sp.,[1] and *A. auricula*, Chapman.[2]

Distribution.—Bore 10, 160-186 feet.

Fam. LAGENIDAE.

Genus FRONDICULARIA, Defrance.

FRONDICULARIA LORIFERA[3], sp. nov. (Plate XVI., Fig. 6).

Description.—Test, compressed ovate, with pointed extremities, more acute at aboral end. Edges of test, blunt. Chambers numerous, about fifteen. The surface of each acute V-shaped chamber thickened with redundant shell-growth, especially towards the oral area of each segment.

Dimensions.—Length of type specimen, 4 mm.; greatest width, 1.615 mm.; thickness, .3 mm.

Affinities.—In outline somewhat like the associated species of *Frondicularia* in these borings, viz., *F. inaequalis*. It is distinguished from that form, however, by the wide angle of divergence made by the two upper edges of each segment, and the exceptionally heavy shell with thick, strap-like layers of redundant growth on the lateral surfaces of the test.

Distribution.—Bore 4, 163-170 feet. Bore 11, 438-440 feet.

Fam. ROTALIIDAE.

Genus CARPENTERIA, Gray.

CARPENTERIA PROTEIFORMIS, Goës. (Plate XVI., Fig. 7).

Carpenteria balaniformis, Gray, var. *proteiformis*, Goës, 1882, K. Svenska Vet.-Akad. Handl., vol. xix., No. 4, p. 94, pl. vi., figs. 208-214; pl. vii., figs. 215-219.

Observations.—This species is found both in the Balcombian and Janjukian faunas; in the former at Muddy Creek (lower beds), and in the latter at Batesford.

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1. *Trochammina robertsoni*, H. B. Brady, 1876. Mon. Carb. and Perm. Foram. (Pal. Soc.), p. 80, pl. iii., fig. 6. *Ammodiscus robertsoni*, Brady sp. Chapman, Ann. Mag. Nat. Hist., ser. 6, vol. xvi., p. 318, pl. xi., figs. 15-17.
2. Chapman, loc. supra cit., 1895, p. 319, pl. xi., fig. 18.
3. Deriv. *Lorus*, a strap; *fero*, I bear.

The specimens from the polyzoal rock of the Mallee borings are invariably arrested in growth, showing only the first tier of segments above the primordial group.

Distribution.—Bore 11, 540-542 feet; 544-546 feet; 560-562 feet.

Genus PULVINULINA, Parker and Jones.

PULVINULINA SCABRICULA, Chapman.

Pulvinulina scabricular, Chapman, 1910, Proc. Roy. Soc. Vict., vol. xxii. (N.S.), pt. ii., p. 288, pl. ii., figs. 2a, b.

Observations.—This distinct little species was hitherto known only from the Batesford limestone. It is here moderately common, and restricted to the polyzoal rock of the Mallee bores.

Distribution.—Bore 11, 540-542 feet; 554-556 feet.

PULVINULINA CALABRA, Costa sp. (Plate XVI., Figs. 8*a*, *b*).

Rosalina calabra, Costa, 1856, Pal. del Regno di Napoli, pt. ii., pl. xiv., figs. 6*a-c*.

R. thiara, Stache, 1864, Novara Exped., Geol. Theil, vol. i., p. 279, pl. xxiv., figs. 29*a-c*, 30*a-c*.

Observations.—This remarkable and distinct species was figured by O. G. Costa from the Italian Tertiaries, but not described. There is no doubt about its identity with our Mallee bore specimen.

The *Rosalina thiara* of Stache is synonymous with Costa's species. It was described from the Tertiary marl of Whaingaroa Harbour, N.Z., which yields a microzoal fauna closely resembling that of the deeper parts of the Mallee bores.

The test of our specimen is slightly rough, and is in the form of a depressed nautiloid spiral, flatter on the superior face, which shows a many-chambered, short, segmented whorl with constricted sutures, closely and densely coiled on the central axis. Underside somewhat concave, showing the outer whorl. Septal face where fractured shows the shell-wall to be thick.

Dimensions.—Diameter of test, 3.84 mm.; thickness, 1.25 mm.

Distribution.—Bore 5, 163-175 feet.

Genus GYPSINA, Carter.

GYPSINA HOWCHINI, Chapman.

Gypsina howchini, Chapman, 1910, Proc. R. Soc. Vict., vol. xxii. (N.S.), pt. ii., p. 291, pl. ii., figs. 4*a*, *b*., pl. iii., figs. 3-5.

Observations.—This species was hitherto only known from the Batesford Limestone. Typical specimens were found in the present bores as follows:—

Bore 3, 226 feet. Bore 5, 162-163 feet. Bore 11, 440-442 feet.

Fam. NUMMULINIDAE.

Genus POLYSTOMELLA, Lamarck.

POLYSTOMELLA STRIATOPUNCTATA, F. v. M. sp, var. EVOLUTA, nov.
(Plate XVI., Fig. 9).

Description.—This variety is very distinct from the type-form in having the earlier whorls exposed on the umbilical area. The latter is depressed and wide, compared with that of the specific form. The retral processes in this variety are strongly developed, and the interspaces, especially on the last whorl, are circular and deep towards the inner boundary of the whorl.

Diameter of test in figured specimen, .466 mm.

Observations.—Typical examples of the species itself are also found in these bores; as, for instance, in Bore 11, 170-175 feet, and in the later deposits, but more sparingly than the variety above described.

An evolute variety of the above species has lately been described by Messrs. Heron-Allen and Earland, from Selsey and Bognor in Sussex, under the varietal name of *selseyensis*.[1] That variety was recorded as "both recent and fossil" (probably pleistocene). It differs from the present evolute variety in having an encrustation of redundant shell-growth over the umbilicus, which is, moreover, not so wide nor so deep as in our variety.

Distribution.—Bore 9, 263-273 feet. Bore 10, 160-186 feet; 195-225 feet; 296-306 feet.

Genus OPERCULINA, d'Orbigny.

OPERCULINA VENOSA, Fichtel and Moll sp.

Nautilus venosus, Fichtel and Moll, 1798, Test Micr., p. 59 pl. viii., figs. *e-h*.

Amphistegina cumingii, Carpenter, 1859, Phil. Trans., p. 32, pl. v., figs. 13-17.

Nummulites cumingii, Carp., H. B. Brady, 1884, Rep. Chall., vol. ix., p. 749, pl. cxii., figs. 11-13, woodcut, fig. 22.

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1. Journ. R. Micr. Soc., 1909, p. 695, pl. xxi., figs. 2a-c (var. of *P. striatopunctata*); name given as *P. striatopunctata*, var. *selseyensis*, Iidem, ibid, 1911, p. 448.

Nummulina venosa, F. and M. sp., Chapman, 1895, Proc. Zool. Soc. Lond., p. 47.

Observations.—This interesting species occurs twice in these bores. It was accepted as a nummulite by Dr. H. B. Brady in his work on the "Challenger" foraminifera (loc. supra cit.), but he did not seem quite convinced that it belonged to that genus, for he says,[1] "On the whole I am inclined to agree in this latter determination" [as a nummulite by Carpenter] "notwithstanding the fact that in any large collection of specimens there are invariably a certain number in which the segments of the final convolution spread out radially, so as to impart an *Operculina*-like aspect to the shell."

In my own cabinet there is a series of tests of this form from the East Indian Archipelago, which shows extreme modification, ending with the typical *Operculina*.

Operculina venosa is found on parts of the Australian coast at the present day, in the neighbourhood of the Great Barrier Reef.

Distribution.—Bore 1, 215-244 feet. Bore 11, 566-568 feet.

SPONGIAE.

CALCISPONGIAE.

SPICULES, indet.

The spicules of calcareous sponges enumerated in the lists of fossils from the borings are all of the tri-radiate type, and conform to figures 4, 5 and 6 of plate iii. in Dr. Hinde's description of *Plectroninia halli* in their outline, but are more than twice the size.[2] No precise identification is, however, attempted here.

ANTHOZOA.

HEXACORALLA.

Fam. TURBINOLIIDAE.

HOLCOTROCHUS CRENULATUS, Dennant. (Plate XVII., Fig. 10.)

Holcotrochus crenulatus, Dennant, 1904, Trans. R. Soc. S. Austr., vol. xxviii., p. 3, pl. ii., figs. 4*a-c*.

Observations.—This neat little coral is not easily confused with the only other known form of the genus, *H. scriptus*, for the latter differs in its more broadly-ovate transverse section, and in the horozontal scribing of the costae; whilst the surface of the thecal wall in *H. crenulatus* is granulate.

1. Loc. supra cit., p. 742.
2. Quart. Journ. Geol. Soc., vol. lvi. 1900, pp. 50-69, plts. iii.-v.

This is the first recorded occurrence of *H. crenulatus* as a fossil. Except for a slight weathering of the external surface, the two specimens found here are in every way comparable with the recent examples in the Dennant collection, from South Australia. These were obtained by Dr. Verco at Cape Borda (15 fms.); St. Vincent's Gulf; and Backstairs Passage (22 fms.).

The related *H. scriptus*, also found recently in Backstairs Passage, S.A., at 22 fathoms, was originally described by Mr. Dennant from the Tertiary of Muddy Creek, and supposed by that author to come from the lower beds. The pink, ferruginous appearance of the type specimen now in the National Museum collection suggests, however, that it came from the red limestone between the Balcombian and the Kalimnan series at Muddy Creek, and about which there is now evidence for believing it to be of Janjukian age. The rolled examples of *H. scriptus* found by Dr. T. S. Hall, came from the Kalimnan of Forsyth's Grange Burn, Hamilton.

Distribution.—*H. crenulatus* occurs in Bore 11 of this present series at 197-199 feet, associated with Kalimnan fossils.

OCTOCORALLA.

PSEUDAXONIA.

Fam. ISIDAE.

Genus MOPSEA, Lamaroux.

MOPSEA TENISONI, sp. nov. (Plate XVII., Figs. 11*a*, *b*, 12*a*, *b*, 13 and 15*a-c*; Pl. XIX., Fig. 39).

Isis sp., Tenison Woods, 1862, Geol. Observations in S. Australia, plate facing, p. 73, fig. 6.

(?) *Isis dactyla*, Id., palaeont. New Zealand, pt. iv., 1880, p. 7, pl. i., fig. 1.

cf. *Isis* sp., Duncan, 1875. Quart. Journ. Geol. Soc., vol. xxxi., p. 674, pl. xxxviiiA, figs. 1-4.

Isis sp., Id., 1875, ibid., p. 675, pl. xxxviiiB., fig. 4.

Preliminary Note.—Tenison Woods in 1880 figured and described some fossil remains possibly identical with the above species under the name of *Isis dactyla*, from Hutchinson's Quarry, Oamaru, but they were so badly preserved as to preclude an exact comparison. It seems better, therefore, to give a distinctive name, in honour of T. Woods, who actually figured this form in 1862 from the Mt. Gambier deposits. In his description of the fossils, he states, amongst other points, that "The condyles are convex or sub-conical, concentrically

striate,'' but he does not mention the radial striae seen in our form. Judging from an examination of several hundred examples of the calcareous internodal joints of *Mopsea* from the Mallee bores, Tenison Woods' specimens may have been abraded, so that the fine, salient radii were cleared away, leaving only the more deeply-marked concentric growth stages of the calcareous part of the axis. Specimens in the present collection show both conditions.

Description.—Calcareous joints forming the internodes, circular to elliptical in transverse section; short and wide when from the base of the coral; longer, to extremely slender and circular in section where forming the middle and distal joints. Sides straight to incurved, and slightly dilated at the ends, especially in the terminal joints; with numerous, fine linear ridges or striae. Articular facets flat to conical, with strong concentric rings of growth and numerous fine radii. The concentric rings are undulate, and outwardly concave to meet the axial radii at the cusps. The radii are in systems of eight, and these, with the concentric lines, produce a very ornate effect on the articular surface in well preserved specimens. The striae of the cylinder correspond with the radial lines of the condyles.

Microscopic Structure of the Calcareous Internodes.—A transverse section of the joints shows that the axis is built on a system of eight rays which send off secondary and tertiary branches; and these consist of thin calcareous plates with a slight upward curvature, giving a tegulate appearance to the rays, in section. The inter-radial areas appear to be formed of fused, spicular bodies. Compared with the structure of the calcareous axis in a living *Mopsea* (*M.* cf. *encrinula*, Lamarck sp.), the fossil species here described (*M. tenisoni*) shows fundamentally similar structure, though on a coarser scale. This is probably owing to the rays not having advanced beyond the primitive eight. The tegulate appearance is seen in both the living and fossil species.

Dimensions of Calcareous Joints.—Three typical specimens were selected.

A.—Specimen of a basal joint; 9 × 8 mm. in diameter, 4 mm. high.

B.—A median joint, that is, from the middle branches of the corallum; 2.5 mm. in diameter, 5 mm. high.

C.—A terminal joint; .75 mm. in diameter, 2.25 mm. high.

Distribution.—Bore 1, 215-244 feet. Bore 3, 201-220 feet; 226 feet. Bore 4, 163-170 feet. Bore 8, 210-219 feet. Bore 9, 315-325 feet. Bore 10, 310-320 feet. Bore 11, 267-590 feet.

Spicules Associated in the Deposits with Mopsea.—Alcyonarian spicules are not uncommon in the finest washings of the polyzoal rock of the Mallee bores. They appear to be all of one general type, and without much doubt may be referred to the same organisms as these here described. They agree with certain species of *Mopsea* found round the Australian coast at the present day, and closely resemble those figured under the name of *Mopsea whiteleggei* by Thomson and Mackinnon,[1] a delicate and graceful plume-like form from Broken Bay, New South Wales. The fossil spicules here recorded are fusiform, twisted to a long S-shape, or V-shape, and sparsely covered with short rounded, blunt or square-ended tubercles. They measure from .375 to .4 mm. in length.

MOPSEA HAMILTONI, Thomson sp. (Plate XVII., Fig. 16).

Isis sp., Duncan, 1875, Quart. Journ. Geol. Soc., vol. xxxi., p. 674, pl. xxxviii.a, figs. 5 and (?) 6, 7, 7*a*.

Isis sp., 1, Id., 1880, Palaeontologia Indica (Sind Fossil Corals and Alcyonaria) ser. xiv., vol. i., pt. 1, p. 109, pl. xxviii., figs. 8, 9.

Isis hamiltoni, Thomson, 1908, Trans. and Proc. N.Z. Inst., for 1907, vol. xl., p. 99, pl. xiv., fig. 1.

Mopsea hamiltoni, Thomson sp., Chapman, 1912, Mem. Nat. Mus., Melbourne, No. 4, p. 43, pl. vi., figs. 3*a*, *b*; 4.

Observations.—The calcareous joints of this species are scarce in the present collection, as compared with those of the foregoing *Mopsea tenisoni*. Their differential characters are well defined in most examples, as seen in specimens now figured, in which the radial lines on the condyles are very pronounced and distinctly crenulate.

Duncan's Indian specimens referred to above were from the Gáj Series (Burdigalian); Naigh-Nai Valley, S.W. of Sehwan. Duncan compares these fossils with his previously figured examples from C. Otway, Victoria; and there is no doubt of their close relationship if not identity.

Mopsea hamiltoni is now known from the Cape Otway Series, from King Island, and from the greensands of Kakanui, New Zealand, as well as from three of the borings in the Mallee; whilst a practically identical form occurs in the Gáj Series of India.

Distribution.—Bore 3, 226 feet. Bore 4, 163-170 feet. Bore 11, 342-510 feet.

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1. Mem. Austr. Mus. Mem. iv., pt. 13, Alcyonaria, 1911, p. 678, pl. lxvi., figs. 2, 3; pl. lxiii.

Genus ISIS, Linnaeus.

ISIS COMPRESSA, Duncan. (Plate XVII., Figs. 17*a*, *b*; Pl. XIX., Fig. 41).

Isis compressa, Duncan, 1880, Palaeon tologia Indica (Sind Fossil Corals and Alcyonaria), ser. xiv., vol. i., pt. 1, p. 109, pl. xxviii., figs. 4, 5.

Observations.—Two fragments of the stony axis of the alcyonarian occur in the Mallee bores, which are comparable to the above form. The largest fragment measures 12 mm. in length, and its greatest transverse diameters are 6.25 × 4 mm. In shape it is a flattened cylinder, and is superficially grooved with coarse longitudinal striae. The fractured surface of one of the fragments is, in the central area, discoloured to a bluish black, as if by residual organic staining. The articular surface is nearly flat, and has all the characters of Duncan's figured specimen.

A transverse section of this fossil under the microscope shows it to consist of undulose concentric laminae, with a sub-circular central portion having numerous short radial extensions; and these layers, by accelerated growth along one axis, cause the stem to finally assume an elliptical outline. The cusps of the concentric layers form the costae on the external surface of the calcareous axis.

Duncan's specimens were from the Gáj beds of Tandra Ráhim Khán.

Occurrence.—Bore 3, 226 feet. Bore 11, 495-500 feet.

NOTE ON THE GENERIC AFFINITIES OF THE ABOVE ALCYONARIAN FOSSILS.

Calcareous joints of Alcyonarians have long been known from the Tertiary beds of Southern Australia and New Zealand. These fossils have hitherto been referred to *Isis*. Tenison Woods in 1862 figured a basal joint from the Mount Gambier limestones which he referred to that genus.[1] Subsequently Duncan provisionally referred to *Isis* and *Mopsea* the collection of alcyonarian remains sent to him from Australia (Cape Otway beds), accordingly as the calcareous joints are branched or unbranched.[2] That is to say, if branched, they belong to *Isis*, if not they may belong to *Mopsea*, or are unbranched joints of *Isis*. This view now appears to be erroneous, for in *Mopsea encrinula* branching invariably takes

1. Geol. Obs. in S. Australia: plate facing p. 73, fig. 6.
2. Quart. J. Geol. Soc., vol. xxxi., p. 673.

place on the calcareous internodes.[1] The spicules (sclerodermites) of *Mopsea* are stated to be club-shaped,[2] but the majority of those figured in the "Challenger" report and from the "Thetis" expedition are spindle-shaped, though sometimes approaching the clavate type.

In *Melitodes* the internodes are calcareous with a horny matrix. In the present examples referred to *Mopsea*, the microscopic structure of the joints excludes that genus from consideration, since they are seen to be solidly and originally calcified.

There is, however, at least one species in the present collection which agrees with *Isis*, as seen in the long, and coarsely-grooved joints, and the dense lamellated structure of the axis.

CRINOIDEA.

Fam. COMATULIDAE.

Genus ANTEDON, de Fréminville.

ANTEDON PROTOMACRONEMA, sp. nov. (Plate XVII., Figs. 18*a*, *b*).

Description.—Isolated centrodorsal nearly hemispherical seen from the side; with more than 30 cirrus sockets, arranged in threes and fours vertically, alternate; borders of sockets prominent, with indications of a crenulated surface to the rim. Ventral aspect subcircular, showing the grooves of the radial pentagon, which increase in width near the periphery. Dorsal aspect subpentagonal at base, with a central depression apparently not perforate or permanently open.

Dimensions.—Type: Height of centrodorsal, 1.154 mm; width ventrally, 1.7 mm.

Observations.—Another specimen, probably of this species, and twice the dimensions, occurs in the same sample, viz., Bore 11, 430-432 feet. It is, however, not so well preserved, and consequently is not figured.

Separate brachial ossicles, which may be referable to this or an allied species, are common in the Mallee borings, in the Janjukian series, having a Mount Gambier facies; and also at Batesford, Geelong.[3]

There is still another species of Antedon in the southern Australian Tertiaries, which is found at Torquay, Victoria, and at Mount Gambier. This will be described later, from specimens in the

1. Wright and Studer, Rep. Chall., Zool., vol. xxxi., 1889, Alcyonaria, p. 43.
2. Cambridge Natural History, Coelenterata, 1906, p. 353.
3. See Proc. Roy. Soc. Victoria, vol. xxii. (N.S.), pt. ii., 1910, pl. 305, p. lii., figs. 8*a*-*b*.

National Museum. It is a comparatively large form, with few cirrus sockets and a low centrodorsal.

Affinities.—One of the nearest allied forms to the above species appears to be *Antedon macronema*, Miller sp.,[1] a Feather-star which has been recorded by the "Challenger" from Port Jackson at 30-35 fathoms; and is also found in King George's Sound and Port Stephens.

Occurrence.—Centrodorsals (2 examples). Bore 11, 430-432 feet. Brachials (probably of this species). Bore 3, 226 feet. Bore 4, 163-170 feet. Bore 11, 430-432 feet; 438-440 feet; 440-442 feet; 442-446 feet; 446-448 feet; 457-458 feet; 540-542 feet; 546-548 feet; 558-560 feet; 560-562 feet; 562-564 feet.

Antedon, sp. (Plate XVIII., Fig. 19).

Observations.—A cirrus joint of a larger species than that described above as *A. protomacronema* occurs in the polyzoal limestone of the Mallee. It may be referable to the Mount Gambier and Torquay species before noticed.

Occurrence.—Bore 11, 560-562 feet.

ASTEROIDEA.

PHANEROZONIA.

Genus PENTAGONASTER, Linck.

Pentagonaster sp. (Plate XVIII., Figs. 20, 21).

Observations.—Marginal plates of a large species of Shield-star have already been recorded by Dr. T. S. Hall[2] from the Lower and Upper beds of Muddy Creek; and also from Spring Creek, Waurn Ponds and Batesford.

In the Mallee borings the genus *Pentagonaster* is well distributed through the polyzoal rock series, and represented both by subtriangular plates from the margin, and subpolygonal to rounded plates of the abactinal area. A few of the plates met with are covered with minute tubercles, as in those of the common living *Pentagonaster aurata*.

Occurrence.—Bore 3, 226 feet. Bore 11, 197-590 feet.

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1. See P. H. Carpenter. Report on the Comatulae, Chall. Rep. Zool., vol. xxvi., pt. lx., 1888, p. 212.

2. Proc. Roy. Soc., Victoria, vol. xv. (N.S.), pt. i., 1902, p. 81, pl. xi., figs. 4, 5.

ECHINOIDEA.

CIDAROIDA.

Fam. CIDARIDAE.

Genus GONIOCIDARIS, Desor.

GONOICIDARIS sp. (Plate XVII, Fig. 22).

Observations.—Amongst other cidaroid spines occurring here there is a small spine differing from those of the living *G. tubaria*, Lam. sp.[1] in having the shaft hour-glass shaped, smooth, with blunt apical tubercles; whereas those in *G. turbaria* are always more or less flattened, and tubercular along the shaft, excepting in the case of the secondary spines, which are longitudinally serially granulate. From *Leiocidaris* it differs in the clavate form of the spine.

Goniocidaris (misprinted "Gomocidaris") is recorded by Tate in his "Census of the Older Tertiary Fauna of Australia."[2]

Dimensions.—Length, 8 mm.; greatest width at about one-third from the base, 3.1 mm.

Occurrence.—Bore 11, 530-535 feet.

CLYPEASTROIDA.

Fam. FIBULARIIDAE.

Genus ECHINOCYAMUS, van Phels.

Subgenus SCUTELLINA, Agassiz.

ECHINOCYAMUS (SCUTELLINA) PATELLA, Tate sp. (Plate XVIII., Fig. 23).

Observations.—In 1907 Dr. T. S. Hall[3] described a *Scutellina* tentatively referred to the above species, having a definite marsupium or brood pouch. This structure was new for this order of echinoids, the Clypeastroida.[4] The figured example came from the polyzoal rock near the mouth of the Glenelg River, Victoria, and Dr. Hall also recorded other specimens obtained by him from Mount Gambier in a similar rock. Amongst the score or two tests of the above species in the Mallee bores collection one very fine example with a brood pouch

1. See McCoy Prod. Zool. Vict., dec. 10, 1883, p. 33, pl. c.
2. Journ. Roy. Soc. N.S. Wales, vol. xxii., 1889, p. 251.
3. Proc. Roy. Soc. Victoria, vol. xx. (N.S.), pt. ii., 1907, p. 140, woodcut.
4. H. L. Clark in his description of *Fibularia nutriens* obtained by the "Thetis," off the coast of N.S. Wales (Mem. Austr. Mus., No. iv., 1909, p. 557, pl. lviii., figs. 1-11) refers to that species as "the only clypeastroid known" with a marsupium, he probably not having seen the report quoted.

occurs. In outline it is of an elongate or ovate type, but comes within the limit of variation in the ambital outline assumed by this species. This example measures 8.5 mm. × 7 mm., and was found in Bore 11 at 500-505 feet in white polyzoal rock of the Mount Gambier type.

In one instance (Bore 8, 165-180 feet) an example of this species was found with the periproct inframarginal, but this need not be considered as more than an exceptional character, as such variation is characteristic of the genus as a whole, but not of the species under present notice.

ANNELIDA.

POLYCHAETA TUBICOLA.

Fam. SERPULIDAE.

Genus SERPULA, Linné.

(SERPULA OUYENENSIS, sp. nov. (Plate XVIII., Figs. 24, 25; Pl. XIX., Fig. 42).

Description.—Tube free, stout, hexagonal in section, gently tapering and slightly curved; the cusps formed by the six longitudinal irregular ridges. Exterior of shell annulated by variably spaced rings of growth, producing a roughened appearance on the edges of the ridges. Interior of tube round and polished.

Dimensions.—Figured specimens (co-types). Spec. A.—Length, 5 mm.; width, 2 mm. Spec. B.—Length, 6.5 mm.; greatest width, 1.75 mm.

Observations.—Several forms of worm tubes ascribed to *Serpula* approach the present species, but none seems to exactly match it in its hexagonal and fluted cross section. The specimens are very constant in character. From the shells of *Dentalium* they are typical shell-structure under the microscope (pl. xix., fig. 42).

Occurrence.—Bore 3, 210 feet. Bore 11, 562-590 feet. Fairly common.

Genus DITRUPA, Berkley.

DITRUPA CORNEA, Linné sp., var. WORMBETIENSIS, McCoy. (Plate XVIII., Figs. 26-28).

Ditrupa wormbetiensis, McCoy, 1874, Prog. Rep. Geol. Surv. Vict., pt. 1, p. 22, fig. 4. Chapman, 1905, Vict. Nat., vol. xxi., No. 12, p. 180.

Description.—Tube rather small, slender and tapering; swollen near the apex and truncated from the shoulder of the swelling to

the orifice, the edge of which is thin and sharp. Surface smooth, but for indistinct rings of growth. Occasionally these rings are very thick, and resemble collars.[1] Lengths of two typical examples, 8 mm. and 9.5 mm., respectively; breadths, 1.5 mm. and 1.5 mm. at the apical end.

Observations.—The type species has been described under many names.[2] As a fossil it ranges in Europe from the Middle Eocene to the Pleistocene, and is also found living.

The present variety is more regularly tapering than Brocchi's "*Dentalium*" *coarctatum.*[3] It is closer to Sowerby's "*Dentalium*" *incrassatum*,[4] from which it differs in its more irregular surface and generally smaller size. The latter species is synonymous with *Ditrupa cornea.*

The original specimen referred to by McCoy, from the Janjukian ironstone of Stawell, Victoria, is merely a mould, and the figure given in the Progress Report (loc. supra cit.) hardly coincides with a squeeze which I have taken from the type specimen, and now figured (see pl. xviii., fig. 26). Since McCoy connects this specimen with those from Wormbete Creek, Barwon Valley, there leaves no room for doubt as to its identity. This variety is, so far as known, quite restricted to the Janjukian series in Victoria.

Occurrence.—Bore 3, 201-220 feet; 226 feet. Bore 4, 163-170 feet; 180-190 feet. Bore 5, 163-175 feet; 175-189 feet; 189-190 feet. Bore 6, 150-154 feet; 158-161 feet. Bore 9, 315-325 feet. Bore 10, 254-296 feet; 310-320 feet. Bore 11, 272-315 feet; 331-342 feet; 342-349 feet; 353-370 feet; 448-450 feet.

Ditrupa cornea, L. sp., var. constricta, var. nov. (Plate XVIII. Figs. 29, 30).

Description.—Tube tapering, only slightly curved, broken up into nodosities by constrictions at intervals along the tube. The nodose swellings are generally found at or towards the apical end, thus showing the varietal character to be partly attributable to senility. Tube larger and stouter than in var. *wormbetiensis.*

Occurrence.—Bore 1, 215-244 feet. Bore 3, 226 feet. Bore 4, 163-170 feet; 180-190 feet. Bore 5, 163-175 feet. Bore 10, 310-320 feet.

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1. In this character it resembles *Ditrupa strangulata*, Deshayes. See Monographie, 1826, p. 372, pl. xvi., fig. 28. Also Rovereto, Pal. Ital., vol. iv, 1898, p. 73, pl. vii. (ii.), fig. 15, 15*a-e*. This species or variety is recorded living from the Mediterranean, Southern Ocean, and Atlantic.
2. See Rovereto, G. Palæontographia Italica, vol. iv., 1898. p. 71; and vol x., 1904, p. 29.
3. Conchiologia, vol. ii., pl. i, fig. 4.
4. Min. Conch., vol. i., 1812, pl. lxxix., figs. 3, 4.

Genus SPIRORBIS, Lamarck.

SPIRORBIS HELICIFORMIS, Eichwald. (Plate XVIII., Fig. 31).

Spirorbis heliciformis, Eichwald, 1853, Lethaea Rossica, vol. iii., p. 52, pl. iii., fig. 11. Rovereto, 1904, Pal. Ital., vol. x., p. 59.

Observations.—Several specimens, agreeing in all details of shape and ornament, were found in the present series. Some of them are attached to the interior of bivalved shells.

A similarly ornamented (?) *Spirorbis*, but of much larger dimensions, is figured by Goldfuss[1] from the Oolite and Lias of Germany, under the name of *Serpula convoluta*. Eichwald's species came from the Tertiary (probably Miocene) of several Russian localities, as Zukowie, Zalisce and the districts of Volhynia and Podolia. Rovereto found this species in the Miocene of Ritzing and Neulerchenfeld in Austria.

The fossil recorded as *Spirorbis* sp. from the polyzoal rock (Janjukian) of Seal River, King Island[2] evidently belongs to the above species.

Occurrence.—Bore 8, 160-165 feet. Bore 11, 564-566 feet.

Class POLYZOA.

Suborder CHEILOSTOMATA.

Fam. CATENICELLIDAE.

Genus CLAVIPORELLA, MacGillivray.

CLAVIPORELLA sp. (Plate XVIII., Fig. 32).

Observations.—A zooeium of *Claviporella* was picked out of the material from Bore 5 at 163-175 feet, in the present series. The specimen is important from the fact that it corresponds with the peculiar little iron-stained bodies occasionally found in the Janjukian calcareous sands of Waurn Ponds, and which have been referred to the foraminifer, *Astrorhiza angulosa*.[3]

Fam. MEMBRANIPORIDAE.

Genus SELENARIA, Busk.

SELENARIA MARGINATA, Tenison Woods, var. SPIRALIS, var. nov. (Plate XVIII., Fig. 33).

Description.—The type species, *S. marginata*, is very common throughout the strata in the bores referable to the Kalimnan and

1. Petrefacta Germaniae, vol. i., 1837, p. 228, pl. lxvii., figs. 14a-f.
2. Mem. Nat. Mus., Melbourne, No. 4, 1912, p. 45.
3. Trans. Roy. Soc. S. Aust., vol. viii, 1886, p. 160.

Janjukian series. Some of the forms, however, nearest the little variety *lucens*, MacGillivray,[1] with the polished dorsal surface have a distinct spiral arrangement of the zooecia viewed from the lower or ventral aspect of the zoarium. Another feature invariably accompanying this varietal character, and which is sometimes met with in other species of the genus, is the inclusion of a little glauconite pebble in the centre of the zoarium on its lower side. This probably formed a point of attachment for the initial zooecium.

Dimensions of figured specimen (type): 1.87 mm. in diameter.

Occurrence.—Found in strata referable to the base of the Kalimnan and the top of the Janjukian.

Bore 5, 155-159 feet. Bore 8, 165-180 feet; 180-199 feet; 210-219 feet. Bore 9, 254-256 feet; 263-273 feet; 315-325 feet. Bore 10, 230-254 feet; 254-296 feet. Bore 11, 199-209 feet.

Fam. LEPRALIIDAE.

Genus LEPRALIA, Johnston.

LEPRALIA GIPPSLANDII, Waters. (Plate XIX., Fig. 43).

Lepralia gippslandii, Waters, 1882, Quart. Journ. Geol. Soc., vol. xxxviii., p. 509. MacGillivray, 1895, Trans. R. Soc. Vict., vol. iv., p. 77, pl. x., fig 21.

Observations.—Four typical examples of this species were found in a sample from Bore 5, at 175-189 feet. They form an encrusting layer upon a species of *Cellepora*.

The species appears to have been hitherto confined to the locality of Bairnsdale.

Fam. SMITTIIDAE.

Genus PORINA, d'Orbigny.

PORINA GRACILIS, M. Edwards sp.

Porina gracilis, M. Edwards sp., MacGillivray, 1885, Trans. R. Soc. Vict., vol. iv., p. 103, pl. xiv., figs. 21-24.

Observations.—The usual form of the zoarium in these deposits (polyzoal rock) is the lobed, bilaminate variation. In connection with this it is interesting to note that MacGillivray (loc. supra cit.) says, " The lobate form is that usually found recent, while the great majority of the fossil specimens are cylindrical."

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1. Trans. Roy. Soc., Vict., vol, iv., 1895, p. 48.

Class BRACHIOPODA.

Fam. TEREBRATULIDAE.

Genus TEREBRATULINA, d'Orbigny.

TEREBRATULINA FLINDERSI, sp. nov. (Plate XVIII., Fig. 34*a-c*).

Description.—Shell small, elongate ovate, with tapering beak. Both valves convex, the pedicle valve deeper than the brachial; the latter depressed towards the anterior margin. Beak stout, prominent, with large foramen.

Shell surface ornamented with about 12 strong, ridge-like costae, bifurcated at or near the anterior margin, and beset with squamose scales; costae becoming spinose at lateral margins of shell. Intercostal spaces deep. Concentric lines of growth inconspicuous.

Dimensions.—Length, 4.75 mm.; greatest width, 3 mm.; thickness, 2 mm.

Observations.—This species is well represented in the Dennant collection by specimens from Flinders, from the Mitchell River, and from the Muddy Creek older beds.

T. flindersi differs from *T. triangularis*, Tate,[1] in its more elongate shape and ovate outline, and in the convexity of the brachial valve.

Occurrence.—Two specimens (one of which is the selected holotype), found in Bore 10, 310-320 feet.

Fam. TEREBRATELLIDAE.

Genus TEREBRATELLA, d'Orbigny.

TEREBRATELLA ACUTIROSTRA, sp. nov. (Plate XVIII., Fig. 35*a-c*).

Description.—Shell small, subcircular, compressed, with a prominent beak. Pedicle valve convex in the umbonal area, with slightly concave shoulders, flattened posteriorly. Brachial valve more depressed and only slightly convex in the posterior region. Surface nearly smooth, but under a low power seen to be finely, radially striate.

Dimensions.—Length, 2.23 mm.; breadth, 1.84 mm.; thickness, .75 mm.

Observations.—This species bears some resemblance to the evenly contoured variations of *T. woodsi*, Tate,[2] but is easily separated by

1. Trans. Roy. Soc. S. Aust., vol. iii., 1880, p. 159, pl. viii., figs. 7*a-d*. Ibid., vol. xxiii., 1899 p. 254.

2. Op. supra cit., vol. iii., 1880, p. 161, pl. ix., figs. 10*a-c*.

the prominent beak and the absence of a mesial fold on the brachial valve.

Occurrence.—Bore 11, 430-432 feet.

TEREBRATELLA PORTLANDICA, sp. nov. (Plate XVIII., Figs. 36*a-c*, 37, 38).

Description.—Shell small, roundly oval; outline subangulate. Valves plano-convex. Beak small, pointed, foramen conspicuous; surface of pedicle valve strongly arched dorsally; brachial valve with a shallow, broad sinus, not extensive, turned down to meet the arched fold of the pedicle valve. Shell surface finely punctate, and showing a few faint concentric lines tending to become laminate.

Dimensions.—Length of holotype, 5.75 mm.; width, 5 mm.; thickness, 2.25 mm.

Observations.—This interesting little *Terebratella* is not infrequent in the bores, but never abundant. In only two cases were perfect examples secured, on account of the liability of the valves to easily separate. By its well-developed median septum it is seen to be a typical member of this genus. The above species is of the *Terebratella woodsi* type,[1] but that shell is much heavier, having a larger foramen and comparatively gigantic beak, and with a deeper and more convex brachial valve. At first sight *T. portlandica* might be confused with Tate's *Magasella lunata*,[2] which also occurs in these bores, but may be distinguished by the latter having a typical acute beak with smaller foramen, characteristic of that genus, and a rounder outline to the shell.

In the Dennant collection there is a typical example of the above species from Portland, which was doubtfully referred to *Terebratella woodsi*, and in the same tube are numerous shells of a similar form from Beaumaris. My attention was first directed to this particular species some years ago in the National Museum collection, when sorting over material from the white polyzoal limestone of Portland, at which locality it is a typical fossil.

Occurrence.—Bore 6, 114-150 feet; 154-158 feet. Bore 9, 263-273 feet. Bore 10, 254-296 feet; 310-320 feet. Bore 11, 505-510 feet; 515-520 feet; 525-530 feet; 545-550 feet.

1. Loc supra cit.

2. Trans. R. Soc., S. Aust., vol. xxiii., 1899, p. 256, pl. viii., figs. 3-3*a*.

Genus MAGASELLA, Dall.

MAGASELLA LUNATA, Tate.

Magasella lunata, Tate, 1899. Trans. R. Soc. E. Austr., vol. xxiii., p. 256, pl. viii., figs. 3, 3*a*.

It is interesting to note the occurrence of this rare form in the present series, especially as it was previously found in some South Australian bores, viz., Croydon Bore, near Adelaide, at 400 to 1230 feet, and Murgurdawa Bore, near Wellington, at 213 feet. Tate also records the species from Belmont, near Geelong, and from the Murray River Cliffs at Mannum.

Occurrence.—Bore 9, 315-325 feet; 11, 560-565 feet.

EXPLANATION OF PLATES.

PLATE XVI.

Fig. 1 *a*, *b*, *c*.—*Lithothamnion ramosissimum*, Reuss. Three examples of branchlets. Mallee Bore No. 5, 163-175 feet. × 4.

2.—*L. ramosissimum*, Reuss. Vertical section of a branchlet, showing variable cell-dimensions. Mallee Bore No. 3, 226 feet. × 26.

3.—*L. ramosissimum*, Reuss. Portion of same branchlet in section, showing two conceptacles with included tetraspores (T), the latter transforming into pale green glauconite. × 52.

4.—*Trillina howchini*, Schlumberger. Lateral aspect of test. Mallee Bore No. 4, 163-170 feet. × 13.

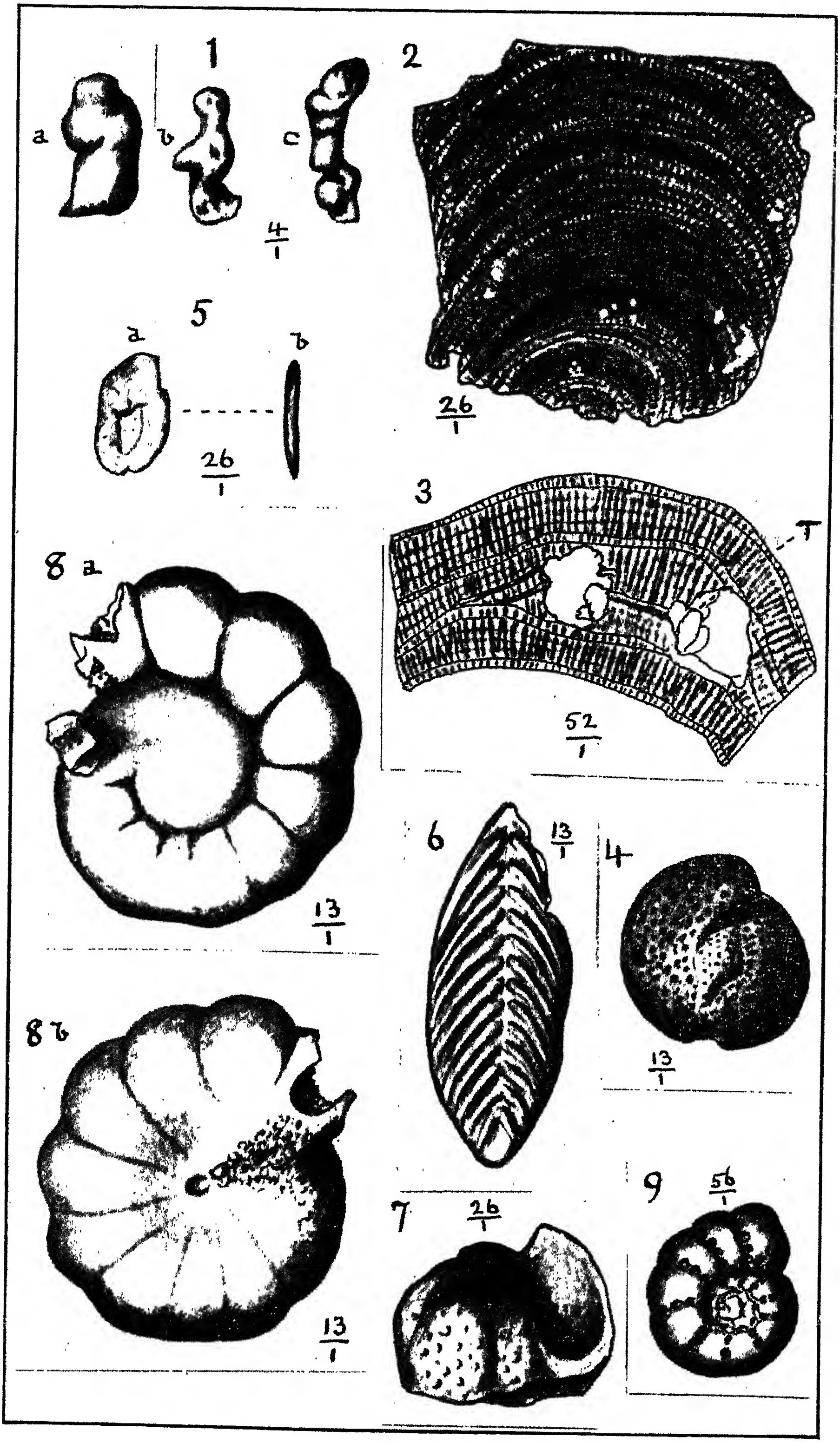
5 *a*, *b*.—*Ammodiscus ovalis*, sp. nov.: *a*, lateral aspect of test; *b*, edge view. Mallee Bore No. 10, 160-186 feet. × 26.

6.—*Frondicularia lorifera*, sp. nov. Lateral aspect of test. Mallee Bore, No. 11, 438-440 feet. × 13.

7.—*Carpenteria proteiformis*, Goës. A young example, consisting of the rotaline basal series of chambers. Mallee Bore No. 11, 540-542 feet. × 26.

8 *a*, *b*.—*Pulvinulina calabra*, Costa sp.: *a*, superior aspect; *b*, inferior aspect. Mallee Bore No. 5, 163-175 feet. × 13.

9.—*Polystomella striatopunctata*, F. and M. sp., var. *evoluta*, var. nov. Lateral aspect of test. Mallee bore No. 9, 263-273 feet. × 56.



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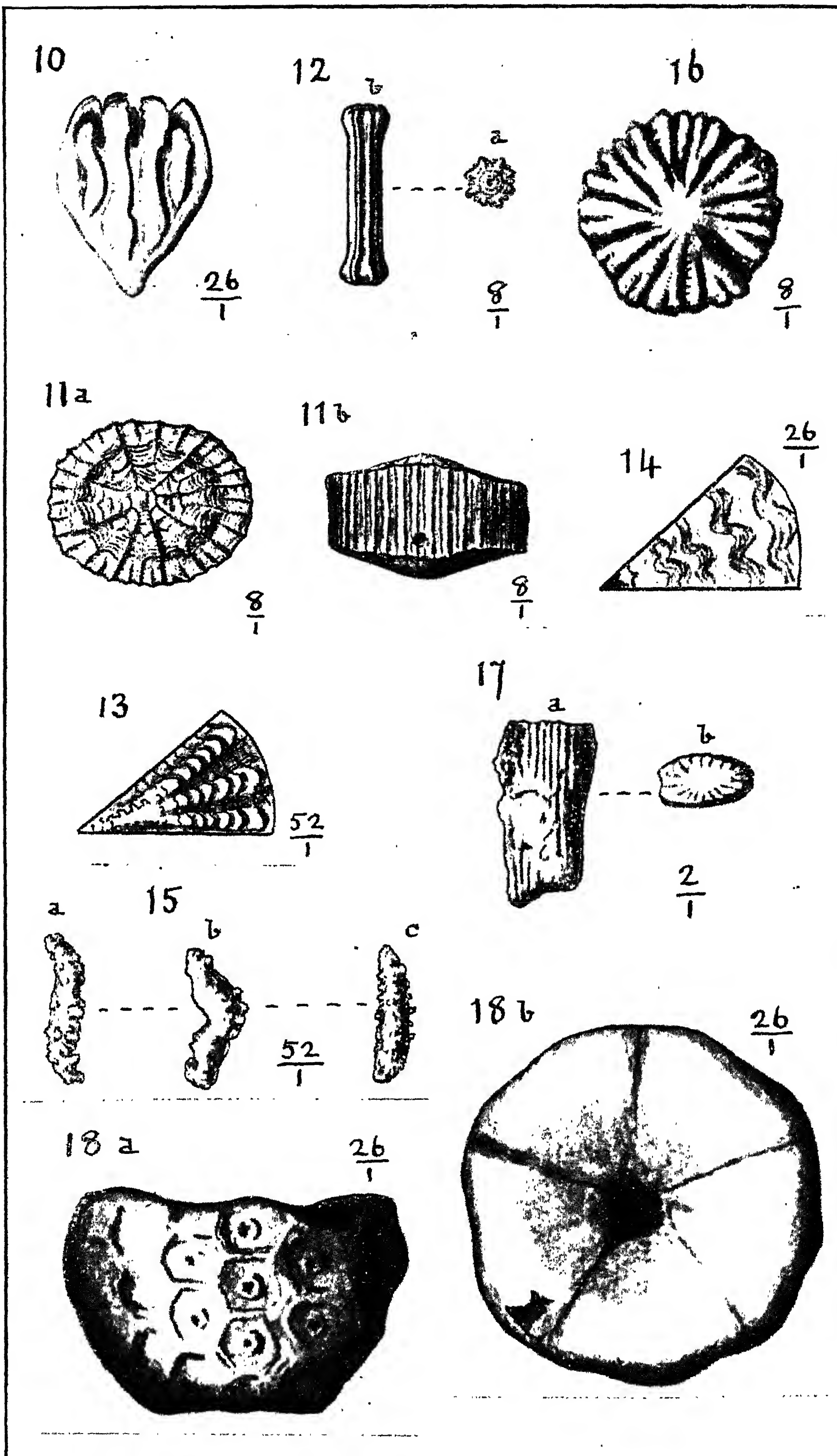
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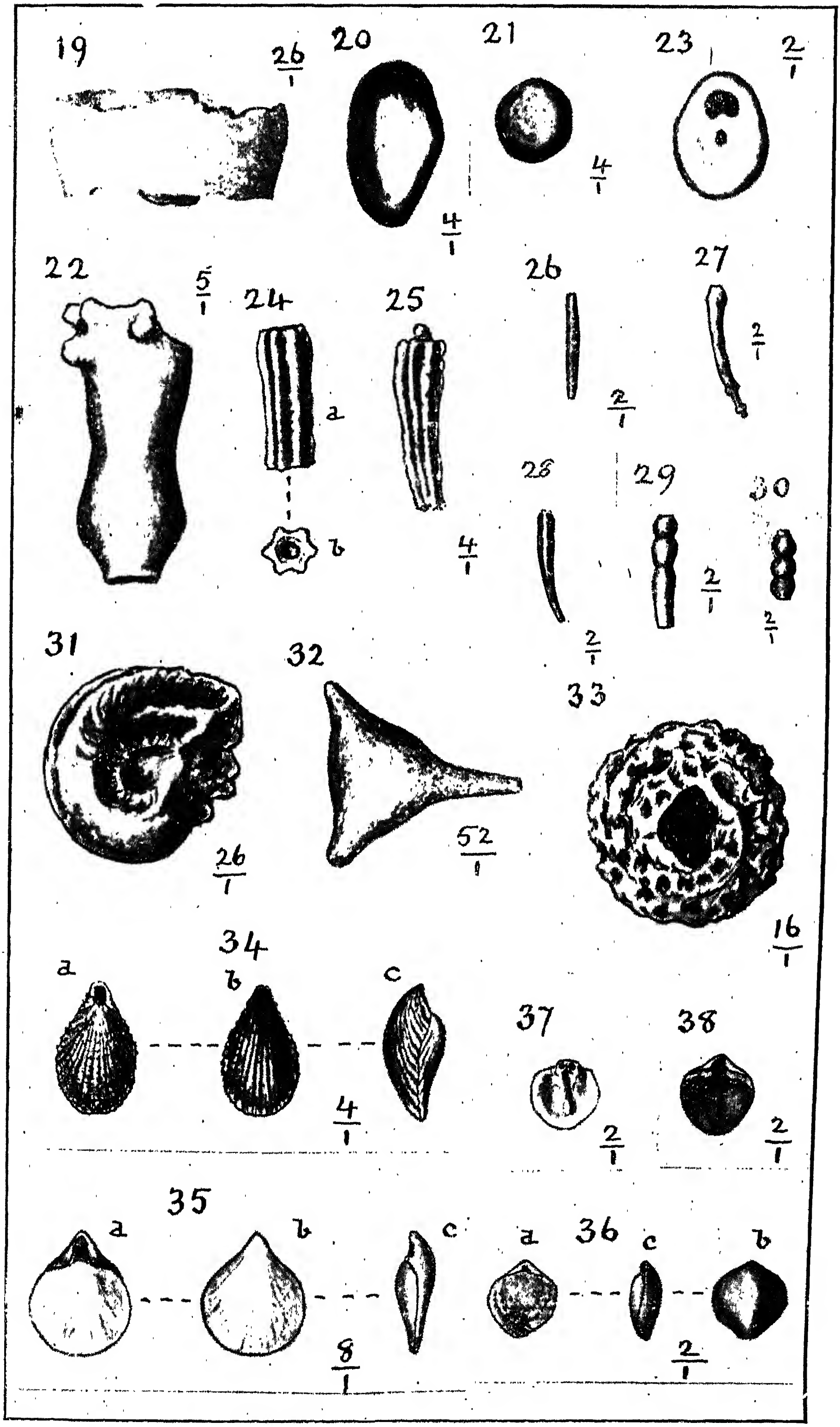

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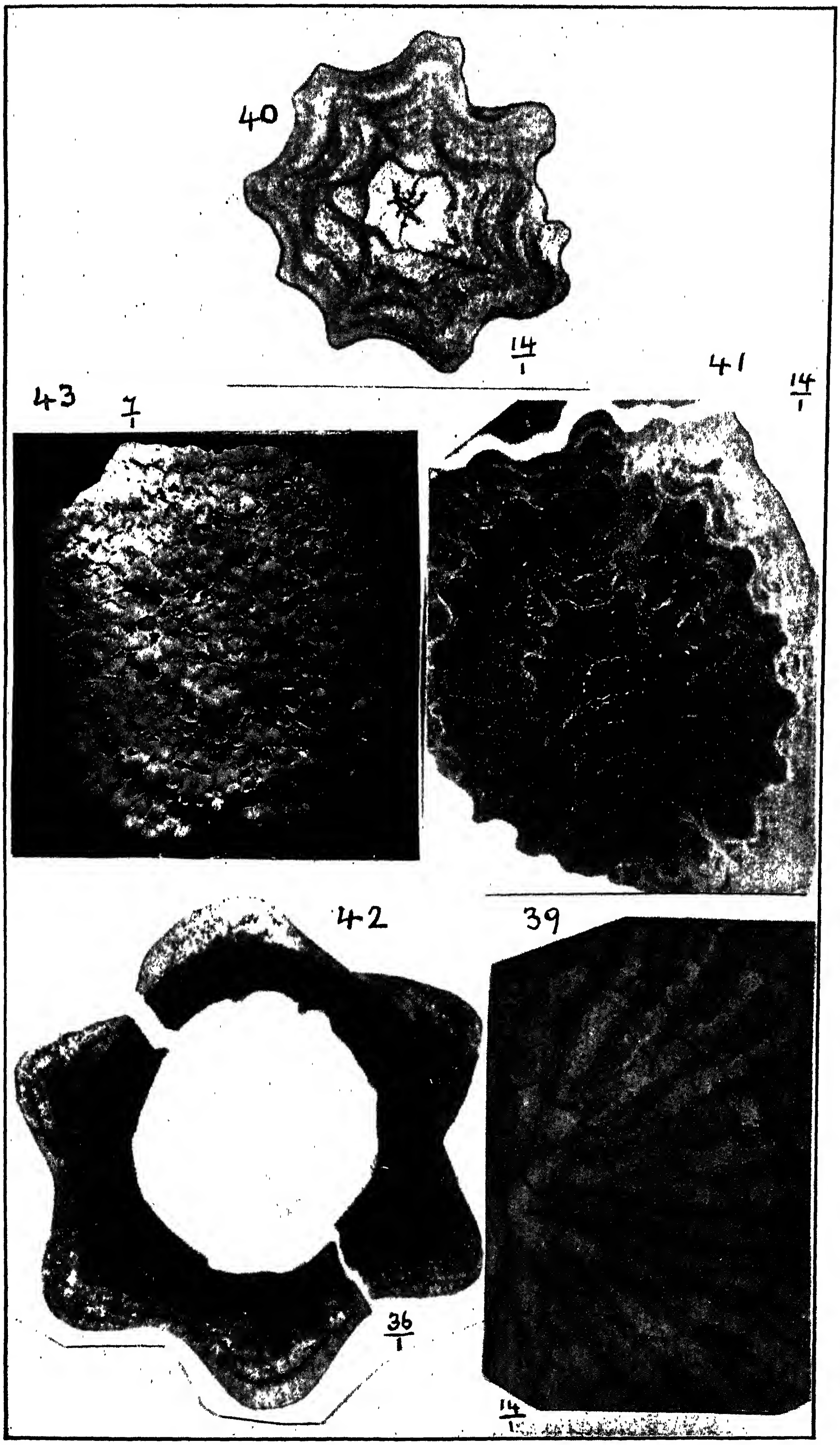


F.C., Photo.

Plate XVII.

Fig. 10.—*Holcotrochus crenulatus*, Dennant. Lateral aspect. Mallee Bore, No. 11, 197-199 feet. × 26.

11 *a*, *b*.—*Mopsea tenisoni*, sp. nov.: *a*, articular face of joint; *b*, lateral surface of joint. Mallee Bore No. 11, 555-560 feet. × 8.

12 *a*, *b*.—*M. tenisoni*, sp. nov.: *a*, articular face of joint near distal end of corallum; *b*, lateral aspect. Mallee Bore No. 11, 544-546 feet. × 8.

13.—*M. tenisoni*, sp. nov. Thin slice of a sector of a joint, magnified to show structure. Mallee Bore No. 11, 495-500 feet. × 52.

14.—*Mopsea* cf. *encrinula*, Lam. sp. (Living). A thin slice of a sector of a joint of the corallum, to show similarity of structure with that of the preceding species. × 26.

15.—*a-c*.—*Mopsea* sp., cf. *tenisoni*, sp. nov.: *a-c*., spicules or sclerodermites. Mallee Bore No. 11, 546-548 feet. × 52.

16.—*M. hamiltoni*, Thomson sp., Articular face of joint. Mallee Bore No. 11, 505-510 feet. × 8.

17 *a*, *b*.—*Isis compressa*, Duncan: *a*, lateral aspect; *b*, articular face. Mallee Bore No. 11, 495-500 feet. × 2.

18 *a*, *b*.—*Antedon protomacronema*, sp. nov.: *a*, centro-dorsal seen from the side; *b*, ventral aspect. Mallee Bore No. 11, 430-432 feet. × 26.

Plate XVIII.

Fig. 19.—*Antedon* sp. Cirrus joint. Mallee Bore No. 11, 560-562 feet. × 26.

20.—*Pentagonaster* sp. Marginal plate. Mallee Bore No. 11, 575-580 feet. × 4.

21.—*Pentagonaster* sp. Rounded plate of the abactinal area. Mallee Bore No. 11, 575-580 feet. × 4.

22.—*Goniocidaris* sp. Hour-glass shaped spine. Mallee Bore No. 11, 530-535 feet. × 5.

23.—*Echinocyamus* (*Scutellina*) *patella*, Tate sp. Actinal surface showing marsupium. Mallee Bore No. 11, 500-505 feet. × 2.

24 *a*, *b*.—*Serpula ouyenensis*, sp. nov.: *a*, side view of large tube (spec. A); *b*, aperture. Mallee Bore No. 11, 585-590 feet. × 4.

Fig. 25.—*S. ouyenensis*, sp. nov. A large tube (spec. B). Mallee Bore No. 11, 585-599 feet. × 4.

26.—*Ditrupa cornea*, Linné sp., var. *wormbetiensis*, McCoy. Type of "*D. wormbetiensis*," McCoy. Cast from mould in ironstone near Stawell. × 2.

27.—*D. cornea*, L. sp., var. *wormbetiensis*, McCoy. Specimen showing annular nodosities. Mallee Bore No. 5, 163-175 feet. × 2.

28.—*D. cornea*, L. sp., var. *wormbetiensis*, McCoy. Typical smooth specimen. Mallee Bore No. 5, 163-175 feet. × 2.

29.—*D. cornea*, L. sp. var. *constricta*, var. nov. Irregularly constricted form. Mallee Bore No. 5, 163-175 feet. × 2.

30.—*D. cornea*, L. sp., var. *constricta*, var. nov. Regularly constricted form. Mallee Bore No. 5, 163-175 feet. × 2.

31.—*Spirorbis heliciformis*, Eichwald. Free or upper surface. Mallee Bore No. 11, 564-566 feet. × 26.

32.—*Claviporella* sp. Zooecium. Mallee Bore No. 5, 163-175 feet. × 52.

33.—*Selenaria marginata*, T. Woods, var. *spiralis*, var. nov. Inferior aspect of zoarium, showing spirally arranged zooecia. Mallee Bore No. 9, 315-325 feet. × 16.

34.—*Terebratulina flindersi*, sp. nov.: *a*, brachial valve; *b*; pedicle valve; *c*, lateral aspect. Mallee Bore No. 11, 310-320 feet. × 4.

35.—*Terebratella acutirostra*, sp. nov.: *a*, brachial valve; *b*, pedicle valve; *c*, lateral aspect. Mallee Bore No. 11, 430-432 feet. × 8.

36.—*Terebratella portlandica*, sp. nov.: *a*, brachial valve; *b*, pedicle valve; *c*, lateral aspect. Mallee Bore No. 11, 525-530 feet. × 2.

37.—*T. portlandica*, sp. nov. Interior of a brachial valve. Mallee Bore No. 6, 154-156 feet. × 2.

38.—*T. portlandica*, sp. nov. Interior of a pedicle valve. Mallee Bore No. 6, 114-150 feet. × 2.

Plate XIX.

Fig. 39.—*Mopsea tenisoni*, Chapman. Transverse section of sclerobasic axis, showing finely tegulate structure of the successive curved layers, and secondary radial arrangement. Mallee Bore No. 11, 585-590 feet. × 14.

Fig. 40.—*Mopsea* cf. *encrinula*, Lam. Transverse section showing coarsely tegulate structure. × 14.

41.—*Isis compressa*, Duncan. Transverse section of axis, showing highly ornate tegulate structure. Mallee Bore No. 11, 495-500 feet. × 14.

42.—*Serpula ouyenensis*, sp. nov. Transverse section of tube, showing laminated inner layer and tubulated outer layer. Mallee Bore No. 11, 585-590 feet. × 36.

43.—*Lepralia gippslandii*, Waters. Mallee Bore No. 5, 175-189 feet. × 7.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. I., 1913].

Art XIV.—*A Revision of the Fossil Volutes of the Table Cape Beds, Tasmania, with Descriptions of New Species and Varieties.*

By G. B. PRITCHARD, D.Sc., F.G.S.

(Lecturer in Geology, &c., School of Mines Department, Working Men's College, Melbourne).

(With Plates XX., XXI.).

[Read 10th July, 1913].

In the year 1895 I revised the Fossil Fauna of the Table Cape Beds, Tasmania, mainly from a collection made by Mr. E. D. Atkinson. Since that time I have had opportunities of examining the beds and of gathering together a fully representative collection of the fauna, as well as noting the specimens and types on view in the Hobart Museum. Lately I have also had the pleasure of examining and naming further material from these interesting beds, collected by Mr. R. N. Atkinson, a son of the above gentleman, and it seems likely that through his enthusiasm and industry many new species will be brought to light, as well as much valuable and additional information on many of the already recorded forms. As a preliminary to a further revision of the fauna as a whole I have thought it well to submit a revision of the Volutes, and include a description with figures of a new species, which has been discovered by Mr. R. N. Atkinson, and by him very generously submitted to me for that purpose.

1. Voluta anticingulata, McCoy.

1874. *V. anticingulata*, McCoy. Prod. Pal. Vic. Dec. i., pp. 24-26, pl. vi., figs. 2-4.

Obs.—The type of this species is in the National Museum, Melbourne, and was obtained from the Bird Rock or Spring Creek Beds, near Geelong. This species was confused by Mr. R. M. Johnston in his Geology of Tasmania with *V. antiscalaris*, McCoy, but that is quite a distinct form; nevertheless, the necessity for correcting the record must not be overlooked. This species may be regarded as a good typical one of this Tertiary horizon, and is certainly also very common in its occurrence, being readily obtainable right throughout the Table Cape section in the uppermost

layers as well as in the lowest. As is usually the case when numerous examples can be gathered of a species, varietal forms can be marked off, and this has already been very ably done by Sir F. McCoy. At least two of his well-defined varieties can be identified.

2. Voluta anticingulata, var. indivisa, McCoy.

1874. *V. anticingulata* var. *indivisa*, McCoy. Prod. Pal. Vic., Dec. i., p. 25.

Obs.—This form is a narrow type with fewer and more sigmoidal ribs. The spiral striae are confined to the anterior base, resulting in a smooth polished body-whorl and ribs, and the absence of the sub-sutural sulcus. This form is commonly represented at Table Cape. The type of this variety is in the National Museum, Melbourne, and was obtained from the Spring Creek or Bird Rock Beds, near Geelong.

3. Voluta anticingulata, var persulcata, McCoy.

1874. *V. anticingulata*, var. *persulcata*, McCoy. Prod. Pal. Vic., Dec. i., p. 25.

Obs.—The type of this variety is in the National Museum, Melbourne, and was obtained from the Spring Creek Beds, south of Geelong. The striking features of this form are the more numerous and straighter costae and the strongly-developed spiral groovings over the whole of the body whorl and spire. Usually a much rarer form than the foregoing.

4. Voluta weldii, T. Woods. (Pl. XX., Fig. 1).

1875. *V. weldii*, T. Woods. Proc. Roy. Soc. Tas., p. 24, pl. 1, f. 2.

Obs.—Another very common form at Table Cape showing an interesting range of variation, quite sufficient to warrant a similar treatment to that adopted in the case of *V. anticingulata*, McCoy. The original description of this species is of an extremely meagre character, but the figure clearly represents the broad, solid, and heavily, but sparsely nodose form, and as the type is in the Hobart Museum there can be no doubt whatever as to the form T. Woods intended to represent his species.

5. Voluta weldii, var intermedia, var nov. (Pl. XX., Figs. 2, 3).

Shell much narrower than the typical form, with a shorter and more blunted apex, more closely and acutely nodose, nodes numbering nine to twelve on the body-whorl as against about seven in the

typical form. Length 33 mm., breadth 17 mm.; as compared with length 41 mm., breadth 22 mm., in the original description.

This is the more usual form at the Muddy Creek and River Murray Cliffs sections.

Type of this variety from Muddy Creek and in my own collection.

6. VOLUTA WELDII, var ANGUSTIOR, var nov. (Pl. XX., Figs. 4, 5).

Obs.—This form is rather common at Table Cape, and may be characterised by its relative narrowness, acute slope of the spire whorls, continued down to the angulation of the body whorl, and by the very faint development of nodes. Length 30 mm., breadth 14 mm.

Type of variety in my own collection.

7. VOLUTA STROPHODON, var. STOLIDA, Johnston.

1876. *V. strophodon*, McCoy. Prod. Pal. Vic., Dec. iv., pp. 25, 26, pl. xxxvii., figs. 2, 3, 4a, 4b, 4c.

1880. *V. stolida*, Johnston. Proc. Roy. Soc. Tas., p. 36.

1888. *V. stolida*, Johnston. Geology of Tasmania, pl. xxx., figs. 4, 4a.

Obs.—McCoy illustrates well in his prodromus some of the variation to which this species is liable, and marks off figure 3 as the average form, figure 2 as a remarkably short-spired variety, and figure 4 the long-spired variety. McCoy's short-spired variety certainly occurs at Table Cape, and the form which has been named *stolida* by Johnston seems to me but another robust variation of this species. The type of *V. strophodon*, McCoy, is in the National Museum, Melbourne, but the type of *V. stolida*, Johnston, is not in the Hobart Museum, and is probably in Mr. Johnston's private collection. If the latter had been visible a more definite comparison could have been made, and greater surety given. There is no representative of this species in the Hobart Museum.

8. VOLUTA STROPHODON, McCoy, var. BREVISPIRA, var. nov.

1876. *V. strophodon*, McCoy. Prod. Pal. Vic., Dec. iv., p. 26, pl. xxxvii., fig. 2.

Obs.—In conformity with the treatment meted out to our other common volutes in having varietal names for extreme forms, it is only fair to call the specially-conoidal form by a distinctive name, viz., *brevispira*. This form occurs at Table Cape, whilst the very long-spired variety (*longispira* var. nov., McCoy's figures, 4, 4a, b, c), common in the older Tertiary clays of Victoria, has not yet

been collected there to my knowledge. A parallel series of variation in almost all their characters can be made out between *V. strophodon* on the one hand, and *V. weldii* on the other.

9. Voluta tateana, Johnston.

1879. *V. tateana*, Johnston. Proc. Roy. Soc. Tas., p. 37.

1888. *V. tateana*, Johnston. Geology of Tasmania, pl. xxx., figs. 3, 3a.

Obs.—Except for the pullus, this species is of the *V. sarissa* type, which is evidently its analogue in the Muddy Creek Beds, Victoria, so far as general habit is concerned, but its greater proportional length of body whorl to spire is a very distinctive feature, which may at once be seized upon. *V. pueblensis*, Pritchard, from Spring Creek, is another very close ally, and may, in fact, ultimately prove but a variation of this species, when a good series can be obtained, but at present the larger pullus, the more slender habit, and the delicate costation serve to distinguish the Victorian form. In a recent letter from Mr. R. N. Atkinson he mentions a volute of the tateana-sarissa type, a mature shell smaller and much more elongate than *V. tateana* amongst his discoveries. It is not unlikely that this may compare favourably with *V. pueblensis*, or help to bridge the gap between that species and *V. tateana*. Specimens of *V. tateana* are on view in the Hobart Museum, but the type is not amongst them. Tate only records the species from Table Cape on the authority of Johnston, so it is to be presumed that the type is in Mr. Johnston's collection.

10. Voluta mortoni, Tate.

1889. *V. mortoni*, Tate. Trans. Roy. Soc. S.A., vol. xi., pp. 124, 125, pl. ix., figs. 1, 2.

Obs.—The type of this species is in the Hobart Museum. This species also occurs in the Lower Beds at Muddy Creek, W. Victoria, but is usually very thin and fragile.

11. Voluta stephensi, Johnston. (Pl. XXI., Figs. 3, 4).

1879. *V. stephensi*, Johnston. Proc. Roy. Soc. Tas., p. 35.

1888. *V. stephensi*, Johnston. Geology of Tasmania, pl. xxx., f. 1.

Obs.—This large species has so far been only very poorly figured, and at the same time ill-defined, and Professor Tate does not add anything material to our information. Being a large shell, its type

of preservation in the Table Cape Beds is not such as to show all its characters in a decided manner, hence different remarks about the presence, indistinctness, or absence of spiral sculpture. I feel certain that this species is really well sculptured spirally, carrying about 24 well-defined threads on the posterior whorls. It is evidently a close ally of *V. heptagonalis*, Tate, from the River Murray Cliffs, and a critical comparison of serial specimens may show a closer connection than has hitherto been indicated.

The type of this species is apparently inaccessible, thus increasing the difficulty of satisfactorily dealing with it.

12. Voluta ancilloides, Tate

1889. *V. ancilloides*, Tate. Trans. Roy. Soc. S.A., vol. ix., p. 126, pl. iii., f. 7.

Obs.—The type of this species was obtained from the clay beds of Mornington or Schnapper Point, Victoria, and is in the Geological Museum of the Adelaide University. It is well represented in the Table Cape fauna, as most collections have included it, and specimens are on exhibition in the Hobart Museum. A good species and quite distinct from *V. macroptera*, McCoy.

13. Voluta maccoyii, T. Woods.

1877. *V. maccoyii*, T. Woods. Proc. Roy. Soc., Tas., for 1876, p. 95.

1889. *V. maccoyii*, Tate. Trans. Roy. Soc., S.A., vol. ix., p. 126, pl. ii., f. 2.

1896. *V. maccoyii*, Pritchard. Proc. Roy. Soc. Vic., vol. viii., n.s. pp. 95-97.

Obs.—The type of this species is from the Table Cape beds, although the species is also very common in Victoria, especially at the Muddy Creek and Mornington sections. The Victorian representatives are of a thinner and more fragile type than the usual Tasmanian examples. In my opinion *V. polita*, Tate, should be included with this species, but I am afraid that in my endeavour to clear up some of the difficulties surrounding this species in a former paper on the Table Cape fossils, I may have added needless confusion by including *V. lirata*, Johnston. Upon more mature consideration on additional material I must admit that *V. lirata*, Johnston, should be upheld.

14. Voluta lirata, Johnston. (Pl. XX., Figs. 7, 8).

1879. *V. lirata*, Johnston. Proc. Roy. Soc. Tas., p. 37.
1888. *V. lirata, Johnston.* Geology of Tasmania, pl. xxx., f. 10.
(*V. allporti*, Johnston, non 1880).

Obs.—Mr. Johnston's description of this species is:—"Shell ovately fusiform, shining, of 7 whorls, including the smooth pullus of 1½ turns; whorls scarcely convex, and ornamented with fine. slightly curved lirae, regular and distinct above, but becoming indistinct and irregular on body whorl; the interspaces are marked with very fine longitudinal lines of growth; spire with a slightly convex outline, and forming an angle of about 50 deg.; aperture somewhat elliptical, longer than spire; lip simple, emarginate above; columella curved, with four equi-distant distinct oblique plaits; length of shell 48 mil., breadth 21 mil., length of aperture 30 mil., proportional length of body whorl 68-100ths, of penult whorl 16-100ths."

The type of this species was obtained from Table Cape, but it is not in the Hobart Museum, probably in Mr. Johnston's private collection. Professor Tate, in Part II. of "The Gastropods of the Older Tertiary of Australia," pp. 130, 131, when dealing with this species mentions that he had not seen authentic specimens, yet he gives a figure and description of a Western Victorian shell, and calls it *V. lirata*, Johnston. Comparing Tate's description with Johnston's, it is at once seen that they do not agree, hence further confusion, and an erroneous record for the Muddy Creek beds. Professor Tate appears to have entertained some doubt about his treatment of this species, for he proceeds to very briefly describe a close ally as differing by its shorter spire, more ventricose body whorl, and stronger ribs, and names it *V. costellifera*. This name will now embrace the shell figured and described by Tate as *V. lirata*. It is hard to understand how this mistake came about, especially as Mr. Johnston noted that his shell approached closely to *V. McCoyi*, while the shells before Professor Tate were of an entirely different type. *V. lirata*, Johnston (non Tate)), is a good species of the *V. maccoyi* type. It is, however, a much more robust shell, thicker and more solid, commonly with a more obtuse apex, a more convex shell, with lirae on the spire whorls. There can be little doubt that the figure given by Mr. Johnston in his Geology of Tasmania, plate xxx., figure 10, represents this species, although referred to on the explanation of the plate

as *V. allporti*, Johnston. This reference must be an error, for the description given of *V. allporti* precludes the possibility of the illustration being a correct one.

The record of *V. lirata*, from the Muddy Creek Beds, Western Victoria, should be expugned, but more recently the typical Table Cape form of this species has been collected by Dr. T. S. Hall and myself from the coastal beds below Rivernook, near the mouth of the Gellibrand River, W. Victoria.

15. VOLUTA PELLITA, Johnston.

1879. *V. pellita*, Johnston. Proc. Roy. Soc. Tas., p. 36.

1888. *V. pellita*, Johnston. Geology of Tasmania, pl. xxx., f. 2.

Obs.—This species was not recognised by Professor Tate when dealing with our Tertiary Volutes; it is, nevertheless, a good species, and should be accepted. I have elsewhere[1] pointed out some of the more striking differences between this species and *V. ancilloides* on the one hand, and *V. macroptera* on the other.

The type of this species is not in the Hobart Museum, probably it is still in Mr. Johnston's possession.

16. VOLUTA SPENCERI, Pritchard.

1896. *V. spenceri*, Pritchard. Proc. Roy. Soc. Vic., vol. viii., n.s., pp. 98-100, pl. iv., f. 1, 2.

Obs.—The type of this species is now in the National Museum, Melbourne, and is from the Table Cape Beds. It is also recorded from Curlewis in Victoria.

17. VOLUTA ATKINSONI, Pritchard.

1896. *V. atkinsoni*, Pritchard. Proc. Roy. Soc. Vic., vol. viii., n.s., p. 100, pl. iii., f. 1.

Obs.—Type from the Table Cape Beds, and now in the National Museum, Melbourne.

18. VOLUTA HALLI, Pritchard.

1896. *V. halli*, Pritchard. Proc. Roy. Soc. Vic., vol. viii., n.s., p. 101, pl. ii., f. 1, 2, 3.

Obs.—The type of this species was obtained from the Spring Creek Beds, near Geelong (Jan Jukian) and is now in my own private collection. It is, however, a common shell at Table Cape, and on that account may have been in Mr. Johnston's collection,

1. Proc. Roy. Soc. Victoria, vol. viii., n.s., pp. 97, 98.

but if so, his treatment of it is of such an obscure and uncertain character, that it would be the merest guesswork to place it. In 1888 Mr. Johnston gave a figure in the Geology of Tasmania which did not represent *V. allporti*, though purporting to do so. In the same year Professor Tate failed to recognise *V. allporti*, Johnston.

The original description of *V. allporti*, is, "Shell large, ovately fusiform, of six regularly increasing whorls, besides a small pullus, which is too imperfect in the various specimens for description; spire acute; apical angle 45 deg., slightly concave in outline; whorls slightly convex, and only ornamented with fine longitudinal lines of growth; aperture rather narrow, elliptical; lip not expanded into a wing, simple; columella curved, with four distinct slender oblique plaits; length, when perfect, about eight inches, or 200 mil., breadth 65 mil., proportional length of body-whorl about 65-100ths of penultimate 9-100ths."

This species is referred to as the "largest Volute in Table Cape Beds, and has much the general appearance of *V. macroptera* (McCoy) in its young state, but has a smaller pullus, and differs materially in the size, number of whorls, and the absence of an expanded wing."

This description does not agree with *V. halli*, and might confuse two or three species, and in view of the confusion already existing I would recommend the removal of *V. allporti* from our lists.

19. Voluta alticostata.

1889. *V. alticostata*, Tate. Trans. Roy. Soc. S.A., vol. xi., p. 122, pl. v., f. 7.

Obs.—The type was obtained from the older Muddy Creek Beds, W. Victoria, and is in the Geological Museum of the Adelaide University.

20. Voluta macroptera, McCoy. (Pl. XX., Fig. 6).

1874. *V. macroptera*, McCoy. Prod. Pal. Vic., Dec. i., pl. viii., f. 1-4.

Obs.—The type was obtained from the Spring Creek or Bird Rock Bluff Beds, near Geelong, and is in the National Museum, Melbourne. Tate records this species as in the Hobart Museum, but the specimen so labelled that I have examined in that Museum is a young example of *V. halli*. Recently I received a genuine young example of this species from Mr. R. N. Atkinson, and this is the first occasion on which a specimen has come under my notice. The Table Cape specimen is a slight variant on McCoy's species, as it

shows a distinct costation on the earlier spire whorls and a stronger spiral striation. In my former paper I included *V. macroptera* in the list of species requiring confirmation. Professor Tate evidently accepted this, as in his later list, with Mr. Dennant, Correlation Paper, part iii., p. 134, this species was omitted from the Table Cape records.

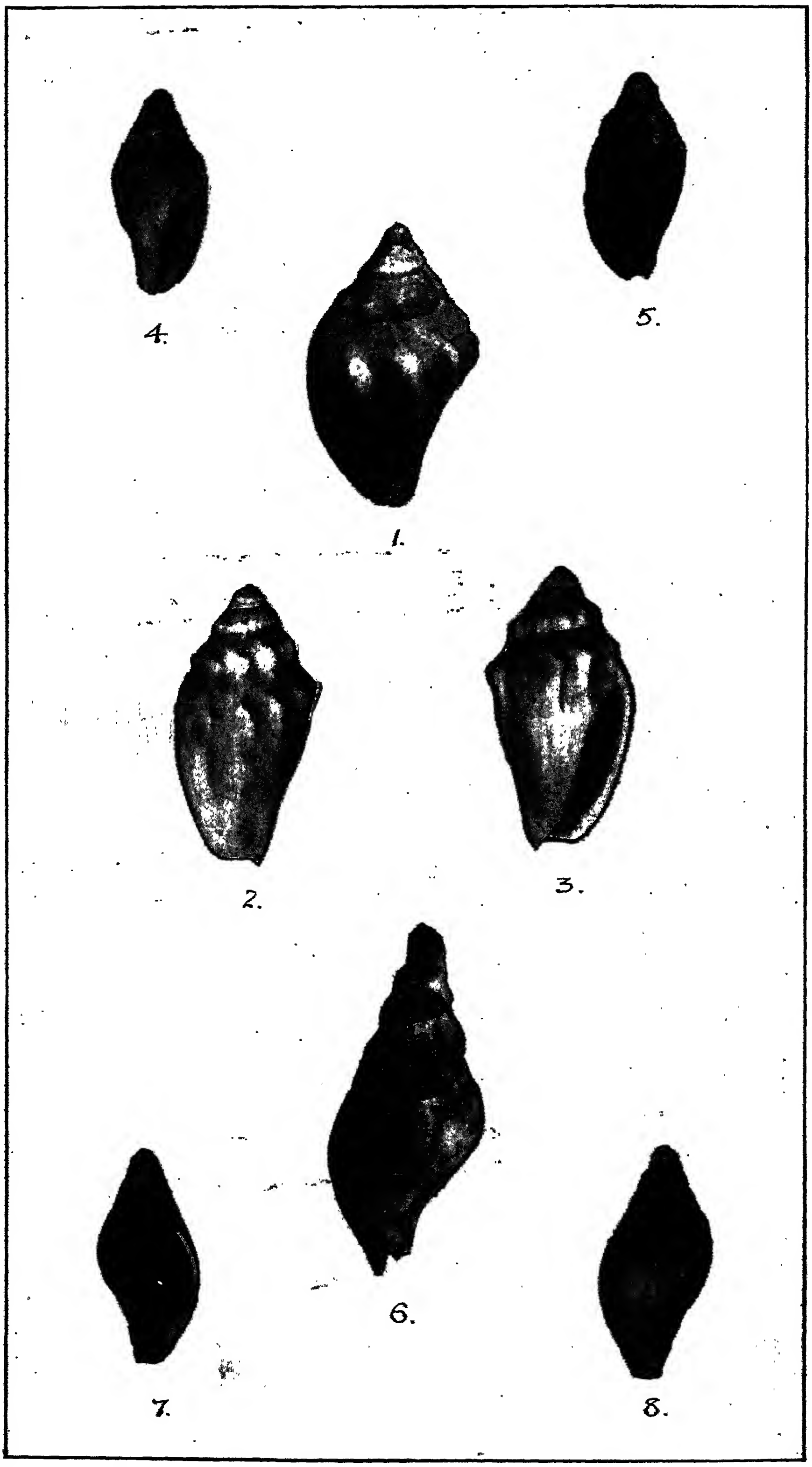
21. VOLUTA WYNYARDENSIS, sp. nov. (Pl. XXI, Figs. 1, 2).

Shell of medium size, ovately fusiform, with an obliquely enrolled mammilate apex, and a few strongly and closely costate whorls ending in a narrowly ovate aperture without a simple margin.

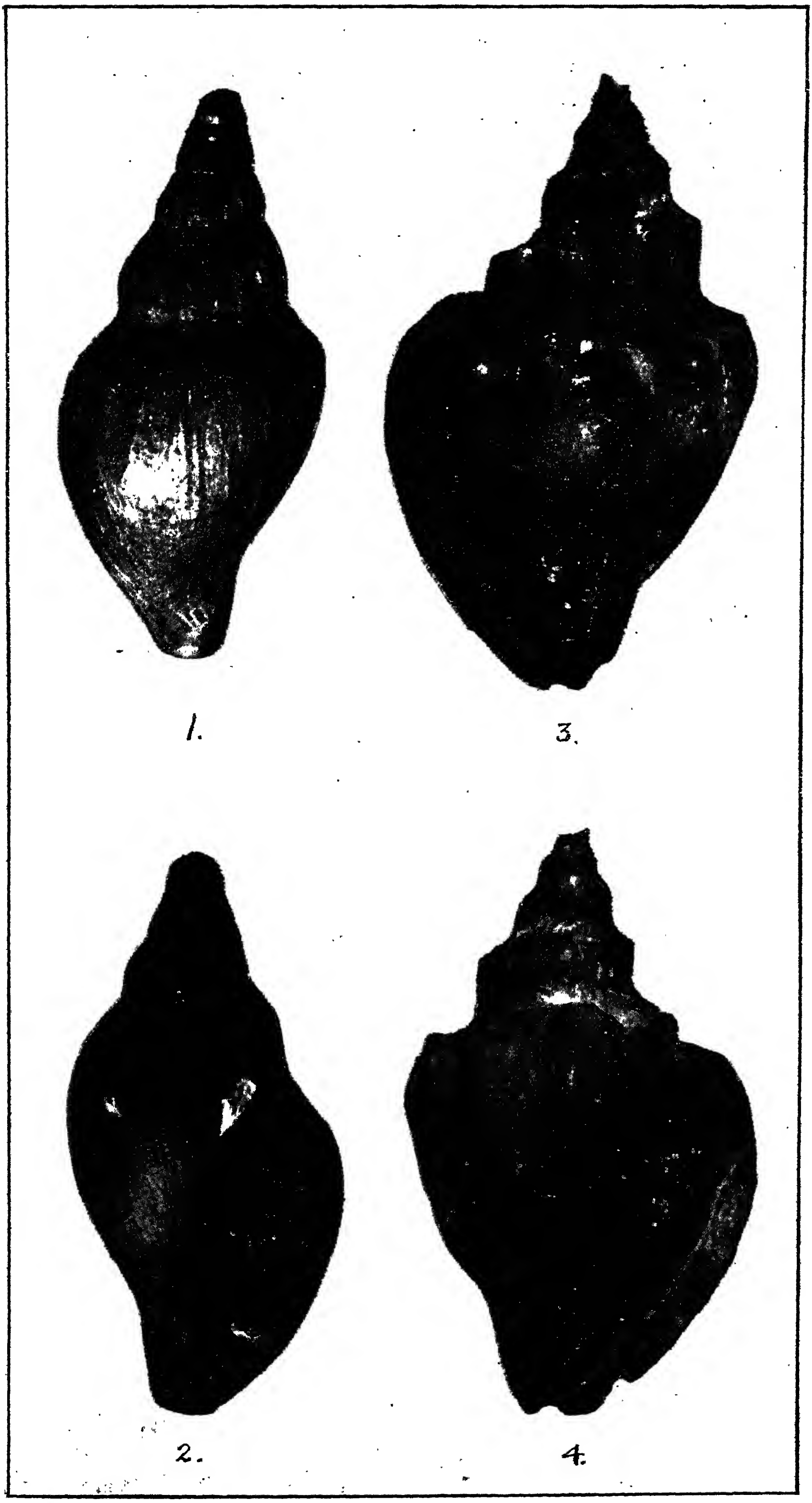
Apical angle about forty-five degrees. The mammilate embryo is made up of two smooth obliquely enrolled whorls, in appearance indicating the probable possession of an exsert tip. Succeeding the embryonic whorls there are about four whorls, flatly convex, a shoulder gradually developing on the second, and increasing to considerable strength on the body-whorl. Distinct overlap of whorls at the suture. Whorls closely and narrowly costate, numbering about sixteen on the earlier spire whorls, increasing to about twenty on the body whorl. The whole surface marked by fine close spiral threads. The body whorl becomes rather broken up by slightly sigmoidal lines of growth, which are much stronger than the spiral threads, but the earlier whorls do not clearly show the lines of growth, while the spiral threads are quite distinct. Aperture narrow, ovate, outer lip ascending slightly at the posterior end, anterior canal relatively broad, but shallow. Columella only slightly twisted, and furnished with four narrow oblique plaits, and smooth enamelled area sharply marked off from the sculptured portion of the body whorl.

Dimensions.—Length, 80 mm.,; breadth, 40 mm.; length of aperture, 47 mm.; breadth of aperture, 16 mm.; breadth of anterior notch, 7 mm.

Obs.—Type from the Table Cape Beds, collected by Mr R. N. Atkinson. A fine species, quite distinct from anything yet described, and in an excellent state of preservation except in regard to the extreme apex, the appearance would seem to point to an exsert tip, but nothing absolute can be asserted in this respect till more specimens are obtained. The specimen as described does not appear to be quite mature, but its characters are very striking, nevertheless. I am in possession of an imperfect specimen, collected by myself from these beds, which probably fits on to this species as a



L. Knibbs, Photo.



L. Knibbs, Photo.

more adult form in which the penultimate and body whorls show the development of strong, high shouldered ribs spaced widely apart, and with a slightly thickened and reverted outer lip.

EXPLANATION OF PLATES.

Plate XX.

Fig. 1.—Voluta weldii, T. Woods (typical).
2.—Voluta weldii, var. intermedia, var. nov.; dorsal view.
3.—Voluta weldii, var. intermedia, var, nov.; front view.
4.—Voluta weldii, var. angustior, var. nov.; front view.
5.—Voluta weldii, var. angustior, var. nov.; dorsal aspect.
6.—Voluta macroptera, McCoy, young example, dorsal aspect.
7.—Voluta lirata, Johnston; front view.
8.—Voluta lirata, Johnston; dorsal view.
The above figures are all natural size.

Plate XXI.

Fig. 1.—Voluta wynyardensis, sp. nov.; dorsal view.
2.—Voluta wynyardensis, sp. nov.; front view.
3.—Voluta stephensi, Johnston; dorsal view; reduced one-half.
4.—Voluta stephensi, Johnston; front view; reduced one-half.

My best thanks are due to Mr. L. Knibbs for the photographs from which these shells are reproduced.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Part I., 1913].

Art. XV.—*On the Estimation of the Position and Slope of the Foramen Occipitale Magnum.*

By L. W. G. BÜCHNER

(Government Research Scholar in the Department of Anthropology, Melbourne University).

(With one Text Figure).

[Read 10th July, 1913].

In 1909 Bolk[1] published a work concerning the estimation of the displacement, position and slope of the *foramen occipitale magnum*.

In describing its position he refers to the fact that in *Mycetes* the *foramen* lies very near "the occipital pole of the skull, so that the condition is found which is the rule with other mammals; sometimes, as in man, it lies about the middle of the cranial base." The same writer[2] also states that, "Together with the variations in position the inclination of the plane of the *Foramen magnum* also generally changes."

As the question of the earlier history of the *foramen occipitale magnum*, and of the base lines from which have been estimated its position and slope has been already fully considered by Bolk, it is unnecessary to pursue the question further in the present paper.

In view, however, of the much more recent work accomplished by this author, on the *foramen occipitale magnum*, it will be necessary for me to examine his methods in some little detail, inasmuch as they form the basis of the present investigation. Bolk introduces a new baseline estimated in the bisected skull. He says, "As frontal point I chose the lowest point of the frontal wall of the skull, where the interior surface . . . bends inwardly in a more or less sharp curve, to be continued in the roof of the nasal cavity." He further states that "the determination of this point presents no difficulties as a rule, since in the median plane the interior surface of all Primate skulls possesses a distinct frontal wall, which may be more or less inclined, and may pass more or less gradually into the cranial wall, but which is still always present."

This author then goes on to say that "in the median all Primate skulls possess a front. On both sides of the median plane this frontal wall disappears, since the roof of the orbitae approaches

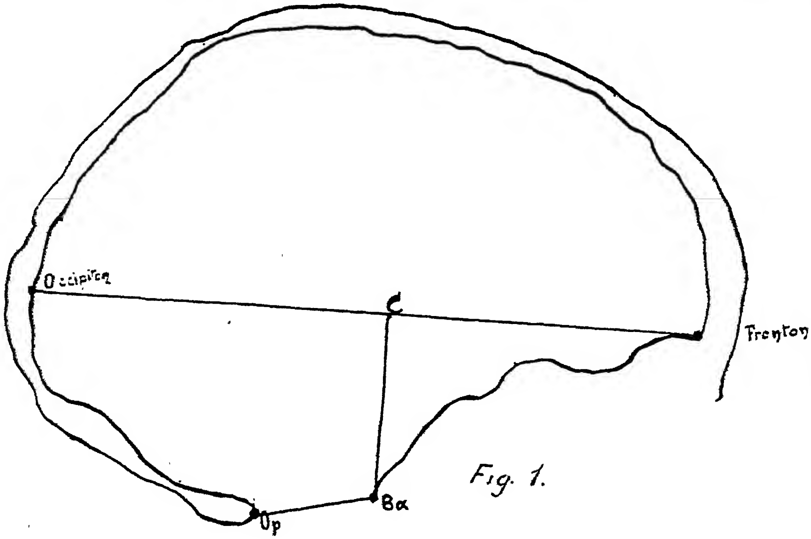


Fig. 1.

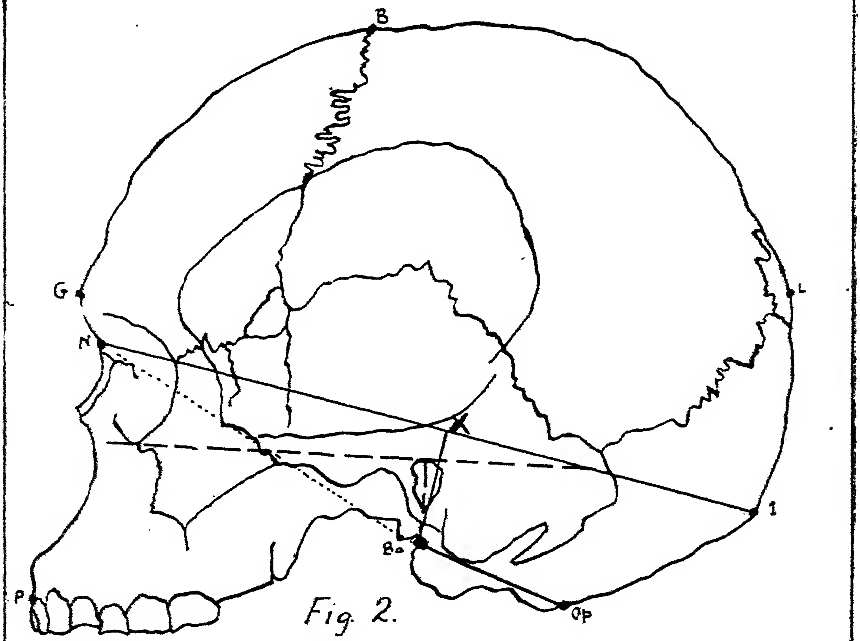


Fig. 2.

very closely under the cranial roof, so that the cranial plane, and the orbital roof join under an acute angle." This anterior point is called the "Fronton."

The posterior cranial point is also obtained on the bisected skull. For its determination the greatest distance from the fronton to a point on the posterior wall is estimated with the aid of compasses. Bolk further says, "With the lower Primates this point can, as a rule, be determined at once." In man, however, and especially in juvenile skulls, it is not so easily estimated. Bolk found that very often no definite point could be determined for the Occipiton, as it is termed, for he found that infrequently "a fairly large part of the interior surface of the skull in the median plane describes a circular arc." Where this was the case, the middle of this circular arc was always chosen as the posterior point."

It is obvious that this base line, from fronton to occipiton, as Bolk himself points out, is determined by the shape and form of the skull, and is thus distinguished from other planes, which are more or less dependent on fixed cranial points. From this base line is determined the position, displacement and slope of the *foramen occiptale magnum*. The position he calculated by means of an index basalis, whilst the slope is determined by the Basal Angle. The former is constructed by dropping a line at right angles from the fronton-occipiton plane, which cuts the basion. This base line is thus divided into two parts at the point C (see fig. 1). As Fc becomes greater it follows that the basion retreats, and this is expressed by the formula

$$\frac{Fc \times 100}{Fo} = \text{Index basalis.}$$

By comparing the basal indices of the anthropoid and man, Bolk found that a considerable difference existed between them, the average indices of the human skulls being 15 units less than that of the anthropoid.

In his second paper, the same author discusses the "slope of the foramen magnum in Primates. The slope is estimated by again employing the fronton-occipiton base line. As before, a line is projected from the base line at right angles, and cutting the basion. From this projected line c Ba (fig. 1) is estimated the inclination of the slope of the *foramen* by calculating the angle which the plane c Ba forms with the basion-opisthion plane Ba Op.

It appears to me that Bolk's methods of determining the position and slope of the *foramen occipitale magnum* are beset by at least

two grave objections. Before a skull can be examined by Bolk's method it must be bisected. This in itself constitutes an almost insuperable difficulty, for, notwithstanding Huxley's[3] now out-of-date dictum that, "it shall be an opprobrium to an ethnological collection to possess a single skull which is not bisected longitudinally," the science of comparative craniology has so far advanced as to render the bisection of skulls unnecessary for modern investigations.

The second objection I find against Bolk's method, is, that there is a difficulty in determining the frontal point. As already defined, this point is "the lowest point of the frontal wall of the skull where the interior surface . . . bends inwardly in a more or less steep curve, to be continued in the roof of the nasal cavity." After examining a number of bisected Australian aboriginal crania, I find it is not always possible to determine this point with accuracy. The crista frontalis is projected into the skull in many cases for several millimetres.

Bolk himself says that in the skulls of the Javanese, with one exception, he found a "frontal crest projecting very far into the cranial space." From this it would appear that a considerable difficulty may be experienced in attempting to determine the exact position of the fronton, for as the crista frontalis projects, so will it affect the basal index. It seems, therefore, that this latter objection, which has been raised, would appear to be a real one. It is, then, difficult to see how Bolk's new base line can ever serve as the basis of a craniometrical system, particularly in view of the objection that it necessitates the bisection of every skull, and without such bisection it is completely useless.

The objects of the present paper are two in number. The first is to record certain observations based mainly on the median sagittal diagrams of some fifty-two Tasmanian crania, and the second is to ascertain from certain of these observations by means of biometric analysis, which method is the best to apply to non-bisected skulls for the determination of the position and slope of the foramen occipitale magnum. The observations I have recorded are eight in number, and are as follows:—

(1) The length of the foramen occipitale magnum, measured from basion to opisthion.

(2) The greatest breadth of the foramen occipitale magnum.

(3) The foraminal index.

$$\frac{\text{Breadth of foramen} \times 100.}{\text{Length of foramen}}$$

(4) Broca's occipital angle. (See fig. 2.) The angle is continued by the nasion-basion, and basion-opisthion planes.

(5) The foraminal angle based on the Frankfort plane. (See fig. 2.)

(6) The nasion-inion length.

(7) The basal index. (See fig. 2.)

(8) The basal angle. (See fig. 2.)

Of the above observations, numbers 1 and 2 were estimated directly on the skull by Professor Berry and Dr. Robertson in 1909, and for permission to utilise these figures I have to express my thanks to these authors. Number 6 has also been recorded elsewhere,[4] by the present writer. The remainder of the observations are the original contribution of the present work, and for which I am responsible.

For determining the position and slope of the foramen occipitale magnum, I have employed three distinct methods.

Of these, the first is Broca's well-known occipital angle, the second is determined by utilising the Frankfort Plane as a base line, and the third is the original method of the present work, and is based on the nasion-inion plane.

As Broca's method is so well known, and has already been referred to, there is no necessity for any further explanation concerning it.

For the second method I have utilised the Frankfort plane as a base line. Bolk has referred to the fact that Huber[5] also determined the slope of the *foramen* by using this plane on non-bisected skulls. Bolk further states that he considers it to be a method which is preferable to others when the skull cannot be bisected. Unfortunately, this work is not available in Melbourne, nor is any abstract of it available. The method which I propose to use, therefore, may or may not be original. In any case, whatever observations are based on the Frankfort plane, will only give the inclination of the slope of the *foramen*, and not its position and situation on the skull base. The method I have adopted is to project a line downwards at right angles to the Frankfort plane, and cutting the basion. The angle which this line makes with the basion-opisthion plane determines the foraminal angle (see fig. 2).

As Bolk also points out, the inaccuracy which accompanies the estimation of angular measurement by direct observation is lessened by constructing projections on a suitable base line. He says, "The position of every point in the skull varies on its own

account, since on every point a large number of factors have a localising influence." Two of these points may have a number of factors in common. Therefore, if in two skulls the angle bounded by these points is found to vary, this difference is not to be accounted for by the shifting of one point only. I have, therefore, estimated the inclination of the slope of the foramen in the manner just described.

The third method of determining both the position and slope of the *foramen* is a modification of that described by Bolk, save that the base lines are different. The base line which I propose to use in the nasion-inion plane. It has been pointed out by Schwalbe,[6] Cunningham,[7] Berry and Robertson,[8] as well as myself,[4] that this plane is an important one in comparative craniology. The several observations recorded by the above investigators all serve to support this contention. Another reason—and a strong one—is, that in Berry and Robertson's Atlas of Tracings of Tasmanian crania[9] the necessary points are accurately denoted, so that observations may be estimated direct from the tracings in the median sagittal plane. My reasons for utilising this plane as a base line would, therefore, appear to be quite valid.

For the determination of the position and slope of the *foramen*, by adopting the procedure already recorded when describing Bolk's method, I have constructed a basal index, and a basal angle. As before a line is dropped at right angles from the base-line—in this case the nasion-inion plane—and cutting the basion (see fig. 2). The basal index is then calculated by taking the ratio, which NX bears to NI, the latter being referred to as 100.

$$\text{Basal Index} = \frac{NX \times 100}{NI}$$

The Basal Angle is likewise determined by estimating the angle which is contained by the two planes, X Ba and Ba Op (see fig. 2). As the method is adopted from Bolk's work, any further explanation is deemed unnecessary.

The material on which the present paper is based will be found in Berry and Robertson's Atlas of Tracings of Fifty-two Tasmanian Crania. All the observations recorded in table I., with the exception of the two already referred to, namely, the length and breadth of the foramen, have been estimated direct from the tracings in the median sagittal plane; that is, in the *norma lateralis*. As number 48 has previously been shown to be that of a juvenile, all the observations recorded on it have been omitted from the table of generalised results.

In Table 1 the generalised results estimated biometrically are set forth. The nature of the observations, the true means, with their probable errors, the standard deviations with their probable errors, together with the minimum and maximum figures for each observation, are displayed in their respective orders.

TABLE I.

TASMANIAN CRANIA.

Nature of Observation.	Number.	Min.	True Mean and Prob. Error.	Standard Deviation and Prob. Error.	Max.
1 - Length of *For. occ. magnum*	37	31	35.78±0.82	2.89±0.22	41
2 - Breadth of *For. occ. magnum*	38	26	29.43±0.27	2.55±0.19	35
3 - Foraminal Index	36	68	82.59±0.59	5.26±0.41	100
4 - Broca's Angle	38	154	163.64±0.59	5 39±0.41	178
5 - Foraminal Angle (Büchner)	33	91	100.24±0.54	4.62±0.38	107
6 - Nasion-Inion Length	45	145	170.97±0.66	6.60±0.46	183
7 - Basal Index (Büchner)	38	43	52.71±0.28	2.69±0.20	58
8 - Basal Angle (Büchner)	38	85	92.71±0.46	4.35±0.33	106

A study of Table 1 reveals some interesting facts. It will be noted that, as judged from the standard deviations, the observations numbers 7 and 8, which are based on the nasion-inion plane, are less variable than 5 or 6, which are estimated by Broca's method, or the Frankfort plane method. The standard deviation for both the Basal Index, number 7, and the Basal Angle, number 8, are shown to be very small.

This, therefore, would appear to support the contention referred to in an earlier part of this work, that the nasion-inion plane is really the best from which to estimate the slope and approximate position of the *foramen occipitale magnum.*

In order to compare the figures of Table 1 with those of other races, I have utilised several plates of Berry and Robertson's Atlas of Australian Crania, in order to obtain the necessary data. As this work[10] is in the hands of the printer, I have to express my thanks to Professor Berry and Dr. Robertson for allowing me to use their original drawings. The observations which I have recorded are taken from the first 52 tracings of Normae A.

The observations which I have recorded are as follows:—

5. Basal Index.
6. Basal Angle.
7. Foraminal Angle (Frankfort Plane).
8. Broca's Occipital angle.

The other source of comparative data I have abstracted from Bolk's works. The generalised results for both the Australian and Bolk's figures are set forth in Tables ii. and iii. respectively.

These results have been obtained in precisely the same manner as those of the Tasmanian, and, therefore, need no further explanation.

TABLE II.

AUSTRALIAN CRANIA.

Nature of Observation.	True Mean and Prob. Error.		Standard Deviation and Prob. Error.
5. Broca's Angle - - -	162.28±0.48	-	5.21±0.35
6. Foraminal Angle (Büchner)	106.98±0.44	-	4.8 ±0.31
7. Basal Index (Büchner) -	52.47±0.24	-	2.60±0.17
8. Basal Angle (Büchner) -	91.72±0.40	-	4.37±0.29

TABLE III.

BOLK'S OBSERVATIONS.

Nature of Observation	True Mean and Prob. Error.		Standard Deviation and Prob. Error.
Index Basalis - - -	45.84±0.26	-	2.74±0.18
Basal Angle - - -	99.68±0.58	-	5.11±0.41

Again, by comparing the observations (7 and 8) based on the nasion-inion plane with those based on Broca's and the Frankfort Plane methods, it will be noted that the former are the least variable.

In Table iv. the results for each observation in the Tasmanian-Australian groups, together with those furnished by Bolk, are set forth in order of their variability. In each instance, the observations based on the nasion-inion plane, which concern the present work, are the least variable, whilst the angular measurements based on Broca's and the Frankfort Plane methods show the greatest variability, which is sufficiently high to preclude them from further consideration.

In conclusion, when further comparative data are available, a better test will be afforded as to the practicability of the original methods herein described. From the material available it is clear that the observations based on the nasion-inion plane are the more accurate. The present work also furnishes another proof that the bisection of crania is unnecessary.

TABLE IV.

Nature of Observation.	Race.	No.	True Mean and Prob. Error.	S.D. and Prob. Error.
Basal Index (Büchner) - -	Australian	- 52 -	53.47±0.24 -	2.60±0.17
Basal Index (Büchner) - -	Tasmanian	- 38 -	52.71±0.28 -	2.64±0.20
Index Basalis (Bolk) - -	Various Races	- 50 -	45.84±0.26 -	2.74±0.18
Basal Angle (Büchner) - -	Tasmanian	- 38 -	92.71±0.46 -	4.35±0.33
Basal Angle (Büchner) - -	Australian	- 52 -	91.72±0 40 -	4.37±0.29
Foraminal Angle (Büchner) -	Tasmanian	- 33 -	100.24±0.54 -	4.62±0.38
Foraminal Angle (Büchner) -	Australian	- 52 -	106.98±0.44 -	4.80±0.31
Basal Angle (Bolk) - - -	Various Races	- 50 -	99.68±0.58 -	5.11±0.41
Broca's Angle - - - -	Australian	- 52 -	162.21±0.48 -	5.21±0.35
Broca's Angle - - - -	Tasmanian	- 38 -	163.64±0.59 -	5.39±0.41

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[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. II., 1914].

Art. XVI.—*On Australian and Tasmanian Coleoptera, with Descriptions of New Species. Part II.*[1]

By ARTHUR M. LEA.

(With Plate XXII.).

[Read 11th September, 1913].

Carabidae.

Xanthophaea.

I have not seen a record as to species of this genus bombarding, but some of them certainly do. This first came under my notice with *X. angustula*, which discharges a small, vague cloud, usually of semi-lunar shape, extending to about two inches from its body. It appears to be discharged outwards and upwards, but occasionally forwards. The amount of vapour is small, and must usually escape observation, but, when about to pick up the beetle, the vapour, if watched for, can be seen in almost every instance. Only one discharge appears to be made, and it is not accompanied by sound.

Dytiscidae.

Necterosoma costipenne, Lea.

The late Rev. T. Blackburn[2] says, "This insect is no doubt identical with *H. penicillatus* Clark." This may possibly be the case, but, if so, it is singular how decidedly (and, between individuals, so uniformly) carinate the Tasmanian specimens are. (Since describing *costipenne*, I have seen hundreds of specimens). Clark says of *penicillatum*, "On either side of the suture an obsolete carination, plainly perceptible when the insect is viewed from in front." In examining *costipenne* from the front, the elytra appear to be feebly concave in the middle, with the carinae less distinct than from any other direction; in fact, from above, they are most distinct (especially along the middle); the word "obsolete" would certainly be misleading applied to all the Tasmanian specimens I

1. Part I. in Proc. Roy. Soc. Victoria, vol. xxii. (n.s.), p. 113, 1909.
2. Trans. Roy. Soc. S. Aust., 1901, p. 125.

have seen. The markings, it is true, vary somewhat, like undoubted specimens of *penicillatum* (my types of *costipenne* were without pale elytral markings), although, as a rule, the pallid portions occupy a much smaller area. I think, therefore, that even if *costipenne* is to be referred to *penicillatum*, it should be regarded as a distinct variety of that species.

Pselaphidae.

Articerus regius, King.

Mr. Cox has recently taken numerous specimens of this species about Sydney.

The male has the front femora strongly inflated, and middle pair still more so, the hind pair, however, are normal. In the original description, King noted the middle pair as being strongly spined; the spine referred to, however, is really on the trochanter; there is also a small tooth on each of the front trochanters. The front tibiae are strongly notched, the notch being marked behind by an acute tooth, and in front by a somewhat obtuse one; the middle tibiae are less conspicuously notched, and the tooth behind the notch is feeble, but the one in front is distinct and acute.

The female differs from the male in being slightly smaller, the legs unarmed, femora comparatively thin and of even thickness, and the hind pair the longest, tibiae not notched, and lower surface of abdomen convex, with the sutures straight.

Both sexes are densely clothed with brick-red pubescence along the middle of the metasternum, the clothing extending to about the middle of the apparent basal segment of abdomen of male, but not quite so far on the female.

Tmesiphorus foveilateris, Lea.

A specimen from Townsville (in the British Museum) differs from the type in being larger (almost 3 mm.), and somewhat darker.

Histeridae.

Chlamydopsis and allies.

Hitherto three generic names have been used in dealing with these curious myrmecophilous beetles, *Chlamydopsis* and *Byzenia*, which are certainly synonymous, and *Orectoscelis*. The late Rev. T. Blackburn, in commenting on the great dissimilarity of the species known

to him, nevertheless referred them all to *Chlamydopsis*, and in this I was content to follow him. But, as the species are now rather numerous, and are certainly allied together in clusters, it seems desirable to propose several new generic names for some of them; as it is certain that other entomologists will not be satisfied to leave them all in the typical genus. I therefore purpose apportioning them as follows:—

Chlamydopsis.	Orectoscelis.	Pheidoliphila.	Ectatommiphila.
agilis	duboulayi	carbo	glabra
cavicollis	humeralis	granulata	opaca
comata		minuta	
detecti		pseudocephala	
ectatommae		sternalis	
epipleuralis			
excavata			
formicicola			
inaequalis			
inquilina			
latipennis			
longipes			
pygidialis			
reticulata			
serricollis			
striatella			
tuberculata			
variolosa			

Orectoscelis.

This genus is unknown to me. To it Mr. Lewis referred *humeralis* and *duboulayi;* also, somewhat doubtfully, *sternalis*. The last named species, however, I purpose transferring to *Pheidoliphila*.

Chlamydopsis.

Regarding *striatella* as the type of the genus, the species may all be distinguished by the prothoracic margins being narrowly, usually unevenly, raised in front, and frequently at the sides. The elytra are widely depressed near the base, with the depression extending to the sides, but towards the margins concealed by raised humeral processes. Of these some species have each shoulder in the form of an epaulette, with two projections behind it; others have the epaulettes split into two projections, which almost meet two subhumeral ones, the raised parts having fascicles or pilose membranes. Hind legs, more or less elongate, and not entirely fitted into grooves.

To this group *comata* and *tuberculata* are now referred as aberrant species, for which, at present at least, it is not desirable to propose new generic names.

Ectatommiphila, n.g.

The species of this genus are nearer the normal *Histeridae* than any of the others. The prothorax is wide and without raised margins. The elytra are transversely impressed behind the base, and the shoulders are not cleft, and are without special clothing. The legs are short, wide, and fitted into grooves.

The two known species occur in nests of *Ectatomma metallicum*.

Pheidoliphila, n.g.

The species of this genus are all small. The prothorax is strongly raised in front, with the raised portions overhanging the head. The elytra are not depressed immediately behind the scutellar region, but there is a depression close to each shoulder; there is an oblique incision at each shoulder, but the shoulders themselves are not raised above the general level, although clothed internally. All the legs are fitted into grooves.

The host of *sternalis* is unknown, but all the other species have been taken from nests of various species of *Pheidole*.

Pheidoliphila minuta, n.sp. (Plate XXII., Fig. 1.)

Reddish-castaneous, prothorax somewhat darker. Clothed with golden setae within each shoulder, elsewhere almost or quite glabrous.

Head small, vertical and feebly concave. Antennae with basal joint large, subtriangular and rather wide. *Prothorax* about thrice as wide as the lateral length, subopaque, smooth and indistinctly punctate; median three-fourths of apex, appearing as a shining, regularly curved, and moderately elevated ridge, each side of which is marked by a subtriangular notch. *Elytra* subquadrate, widest close to base, with a distinct depression within each shoulder; each side at base appearing as a wide obtuse projection, which is conspicuously elevated at the depression, but not elevated above the general level, and obliquely cut off at the outer base; disc regularly convex, with dense and small, but clearly defined punctures. *Pygidium* and propygidium with minute punctures. *Prosternum*, with a deep, wide and almost parallel-sided groove, extending almost its entire length. Metasternum with a feeble median line, and with minute, but clearly defined punctures, similar punctures in basal segment of abdomen. *Legs* rather short, tibiae distinctly flanged, the flanges increasing in width from apex to near base, and then more or less obliquely cut off. Length, $1\frac{1}{2}$ mm.

Hab.—Victoria, near Melbourne, from a nest of *Pheidole* sp. (F. P. Spry). Type in National Museum.

From all the previously described species readily distinguished by the apex of the prothorax; in the other species it is strongly elevated, and more or less bifid; in the present species it is but moderately elevated, not at all bifid, and slopes round with an even curve. *Granulata* at first appears to have the elevated parts evenly curved, but this is really due to two elevations touching in the middle, like a pair of closed nippers. It is the smallest known species of the allied genera.

The type has each antenna withdrawn into its receptacle, so that only the outer face of the basal joint, and the tip of the club are visible; the tip, however, is placed side by side with the basal joint, so that it cannot be seen from above, as in most species of *Chlamydopsis.*

Since the above was written, Mr. Spry informed me that he had taken, in November, ten more specimens clustered together under a stone, in a nest of the same species of ant at Fern Tree Gully, and he kindly gave me four of them, these enabling me to add the following particulars:—The club is of an elongated-conical shape (much like a modern rifle bullet), and distinctly shorter than the first joint, the intervening joints combined are slightly longer than the club. On the prosternum, from each side of the median groove, a line extends, slightly obliquely, to near the sides, where it touches at right angles, a curved line. The tibiae are more or less shallowly concave on both their margins; on the lower side, for their entire length, for the reception of the femora, and on the upper side, for a shorter length, for the reception of the tarsi.

Chlamydopsis detecti, n.sp.

Of a rather light castaneous, legs and tips of subhumeral projections, somewhat darker. Head, front of prothorax and base of elytra, with a few straggling setae; a fairly large, but partially concealed, golden pubescent membrane within each shoulder.

Head vertical and transverse, with small but distinct punctures, and a few small granules. Antennae with basal joint large and curved. *Prothorax* twice as wide as its median length, which is about twice that of each side, disc gently elevated in middle, lateral and apical margins strongly elevated, base oblique from middle to each side, with dense and small, but clearly defined punctures. *Elytra* a trifle wider than long; with a wide irregular depression

near base, each side of scutellar region with a feebly elevated space, within the depression, the hinder margin of each with a few small granules; about each shoulder with two conspicuous processes, the outer one thin and strongly elevated, the inner in the form of a stout, obtuse tubercle, the two separated by a conspicuous groove; immediately behind the two subhumeral processes are two others of somewhat similar form, but with their apices pointed forwards instead of backwards; hind margins obliquely reflexed; a few setiferous granules on each side of suture near middle, and on the inner basal tubercles; punctures small and mostly inconspicuous. *Pygidium* and propygidium large and separately convex. *Under surface*, except four apical segments of abdomen (which are highly polished), subopaque. Intercoxal process of prosternum narrow and with a narrow carina on each side. Metasternum with a narrow median line. *Legs* not very long; all the tibiae with rather wide flanges, ending somewhat abruptly near their bases. Length $4\frac{1}{4}$ mm.

Hab.—Queensland; Dawson River, from a nest of *Iridomyrmex detectus* (E. D. Barnard).

Nearer to *formicicola* than to any other described species, but considerably larger, elytral processes larger and of different shape, with distinct granules, etc.

On the type the antennae are almost entirely withdrawn into their receptacles, so that only the basal joint and a small portion of the club are visible; the club, however, appears to be cylindrical and curved. The margins of the prothorax are so strongly elevated that the disc appears conspicuously concave, its greatest depth being at the front angles; the margin is somewhat interrupted in the middle of the apex. The subopaque parts of the under surface are rendered so by dense minute punctures, and exceedingly minute pubescence.

Chlamydopsis agilis, n.sp. (Plate XXII., Fig. 7.)

Reddish-castaneous, under surface (except prosternum), sides and apex of elytra blackish. A few short pale setae scattered about, but a conspicuous fringe of very short setae on the inner margin of each epaulette.

Head almost vertical, with distinct net-like punctures. Antennae with basal joint large, flat and curved, its outer face with punctures as on head; club subovate, and rather large. *Prothorax* almost twice as wide as the median length, disc regularly and gently elevated, front margins elevated, and in the form of four oblique

lobes, with a median notch, the outer lobes slightly wider than the inner ones, sides feebly decreasing in width from apex to base, and very feebly elevated; punctures as on head. *Elytra* subquadrate, with a wide transverse, irregular depression near base; each side of scutellar region feebly elevated within the depression, and subopaque; each shoulder in the form of a conspicuous epaulette, concave internally above the depression; a feebly notched process close behind each epaulette; middle behind the depression longitudinally and obliquely striated, rest of upper surface and the episterna with net-like punctures. Similar punctures on pygidium and propygidium. *Prosternum* and *mesosternum*, with net-like punctures. Metasternum with a moderately deep median line, continued to base, but not to apex; and, as also the abdomen, with distinct but irregularly distributed punctures. Four front *legs* of moderate length, their tibiae with flanges, which, from some directions, appear to regularly increase in width from base and apex to middle, which appears rather acutely dentate; hind legs very long, their tibiae of very different shape to those of the others. Length, 3 mm.

Hab.—N. S. Wales; Sydney, from a nest of *Ectatomma metallicum* (H. W. Cox).

Allied to *inaequalis* and *longipes*. To the former species at first it appears to be very close, but the hind tibiae are very different. In the present species they are wide for the greater portion of their length, with the upper edge gently rounded off, and the obliquely cut off apex not far from perpendicular. In *inaequalis* the apical slope is much longer, and the whole tibia is considerably narrower, the apex of the prothorax is also not exactly the same. *Longipes* has much longer hind legs, and is otherwise very different. In sending the specimen, Mr. Cox wrote that it was extremely active, a character strikingly at variance with the other species of the genus, but Mr. W. du Boulay, who has recently taken a specimen, wrote that it was quite slow in its movements.

Chlamydopsis inaequalis, Blackb. (Plate XXII., Fig. 8.)

A hind leg of the type of this species is figured for comparison with that of the preceding species.

Chlamydopsis serricollis, n.sp. (Plate XXII., Figs. 2, 3, and 4.)

Black, subopaque; legs of a rather dingy castaneous. Each epaulette, with a conspicuous golden pubescent membrane posteriorly, and with a few stout golden setae.

Head rather small and vertical; with dense punctures, and with four conspicuous granules. Antennae with basal joint large and with punctures as on head. *Prothorax* scarcely twice as wide as the median length; front margin with three conspicuously serrated lobes, median lobe with four teeth of even size, each of the others with four or five teeth of somewhat uneven sizes; each side with two or three conspicuous teeth; a narrow irregularly serrated ridge from middle of disc to apex; with a few conspicuous granules or small tubercles on each side of median portion of disc. *Elytra* somewhat longer than wide, with a conspicuous sub-basal depression; each shoulder in the form of a conspicuously elevated epaulette, with numerous rough granules, sides near base serrated; disc irregularly elevated behind each epaulette, each side of suture with a row of small granules, becoming larger posteriorly; a transverse irregular row of granules at about apical third; apex conspicuously and irregularly serrated; epipleurae with conspicuous striae, all converging to outlets of basal depression. *Propygidium* and pygidium with a few rough granules of irregular size, their junction conspicuously serrated; propygidium in addition with a longitudinal row of granules. *Under surface* densely punctate, the punctures coarser on four front intercoxal processes, and at base of abdomen than elsewhere. *Legs* moderately long, all the tibiae with conspicuous flanges, which at the highest point of each appear strongly dentate. Length $2\frac{1}{2}$ mm.

Hab.—N.S. Wales; Port Hacking, from a nest of *Ectatomma metallicum* (W. du Boulay.)

I was at first inclined to regard the type of this species as representing a variety of *pygidialis;* but it differs from the type of that species in having the margins of prothorax with very conspicuous serrations, the apices of the elytra are similarly serrated, and so is the prothoracic carina as seen from the side (traces of these serrations are to be seen on the type of *pygidialis*). But the hind legs are also different. On the type of *pygidialis* the obliquely cut off hind margin of the hind tibia, containing the tarsal groove, slopes off at a wide angle from the vertical, with its highest point not much more distant from the base than from the apex. On the present species the slope is much shorter, much nearer the vertical, and with the highest point almost twice as distant from the base as from the apex. The present species also has the elytral epipleurae with striae quite regular for the greater portion of their lengths; in *pygidialis* the striation is scarcely noticeable, even at the outlets of the basal depression.

On the type each antenna is fitted into its receptacle so that only the outer face of the basal joint, and the tip of the club, are visible. The whole of the upper surface, and the pygidium and propygidium, are clearly covered with small flattened granules, that from some directions appear almost like scales. Most of them are of uniform size, but occasionally one appears to be slightly larger than its fellows.

Chlamydopsis pygidialis, Blackb. (Plate XXII., Figs. 5 and 6.)

A hind leg of the type of this species is figured for comparison with that of the preceding species.

Rhizophagidae.

Ocholissa humeralis, Fairm.

Some specimens from Cairns sent to Mons. Grouvelle were identified by him as belonging to this species, which does not appear to have been previously recorded as Australian.

Cioidae.

Lyctus impressus, Comolli.

This species is widely distributed in Australia and Tasmania. It has been introduced, and I have to thank Mons. A. Grouvelle for the identification of some specimens sent to him.

Malacodermidae.

Laius hackeri, n.sp. (Plate XXII., Fig 9.)

♂ Flavous; basal half of head black, with a greenish gloss, scutellum black; elytra with base and a triangular continuation along suture, and a subapical angular fascia (touching sides but not suture), metallic blue or purple; under surface (parts of abdomen excepted), and legs black or blackish, knees pale; antennae with two basal joints and a part of third flavous, the others black with rather sparse long hairs, and with short and rather sparse pale pubescence.

Head somewhat flattened and with the face very feebly concave; with small indistinct punctures. Antennae with two basal joints[1] large, and the second curiously distorted. *Prothorax* strongly transverse, almost angularly dilated to apical third; with shallow

1. The third joint is really the one here treated as the second, the true second joint being very small and usually concealed; and as other workers have treated the true second joint as being absent, I simply follow their lead.

indistinct punctures. *Elytra* with dense punctures, sparser and smaller, on blue basal marking than elsewhere. Length, 4¼ to 4½ mm.

♀ Differs from the male in having the two basal joints of antennae simple, and the front tarsi different.

Hab.—Queensland: Cairns, Chillagoe (Henry Hacker).

A medium-sized species, with distinctive elytral markings, and with the second joint of antennae of male very different to that of any previously-described species.

The pale colours have altered somewhat since the specimens were first received, and, unfortunately, they were not noted when fresh. On the elytra the flavous parts appear to be of two shades of colour, both being paler than the prothorax. The subapical fascia, if such it can be called, on the elytra, starts from the sides, where it is widest, and its front margin is angularly produced at its middle, whilst its back margin is triangularly or semi-circularly notched. The basal joint of the antennae is large, and towards its apex has a small conical projection crowned with a seta; the second is longer than the first, and its extreme width greater than its length, its lower surface convex, and upper irregularly concave, and it has two curious projections from the front; the anterior one of these is the larger; is first directed outwards, and then backwards, and terminates in a somewhat curved process, which almost, but not quite, touches a narrow process that represents the outer part of the posterior projection. From some directions the two projections appear to meet in front of a circular opening. The male has the second joint of the front tarsi very small, so that at first the tarsi appear to be four-jointed; in the female the second is of normal size, so that the five joints are clearly visible, and the tarsi appear to be longer.

Laius C.-pupureus, n.sp. (Plate XXII., Fig 10.)

♂ Flavous, basal half of head black, with a purplish gloss, scutellum black; a large spot on each shoulder, and a C-shaped mark near the apex, deep metallic blue or purple; meso and metasternum black with a purplish or metallic green gloss; tip of abdomen infuscate; four hind legs black with a purplish gloss, the front ones, except tibiae, flavous; two basal joints of antennae and part of third flavous, the rest black. With rather long, suberect, pale pubescence, and, in addition, with some longer and usually darker hairs.

Head somewhat flattened in parts, and with minute punctures. Antennae with two basal joints large and distorted. *Prothorax* strongly transverse, sides somewhat angularly inflated to apical third; punctures shallow and indistinct. *Elytra* with very dense punctures, smaller and sparser on humeral markings than elsewhere. Front *tarsi* with basal joint short, second longer, closely applied to it and strongly curved at apex, claw joint unusually large; front femora with a tubercular swelling on middle of upper surface. Length, 6 to 6½ mm.

♀ Differs from the male in having the two basal joints of antennae simple, the second joint of the front tarsi distinct from the second, and the femora simple.

Hab.—Queensland: Cairns (Henry Hacker).

A large species, allied to *tarsalis* and *major;* from both of which it is readily distinguished by the subapical markings of elytra, and different basal joints of antennae of male. From *verticalis* (Macleay, not Fairmaire), of which, so far, only the female is known; it differs in being flatter, and in the shapes of the elytral markings.

The mark on each shoulder covers the whole of the extreme base, is then directed backwards close to the suture to about the apical fourth, and then is directed somewhat obliquely to the side; the subapical mark is strongly curved, and touches the side, but not the suture; on the left elytron it is somewhat C-shaped, and on the right reversed—Ɔ. The basal joint of the antennae is feebly curved on its inner side, and strongly curved on its outer, with the apex almost as wide as the length. The second joint is shorter than the first, but considerably wider, convex on its lower, and irregularly concave on its upper surface; near its anterior outer edge there is a distinct fovea, and posteriorly it is excavated, with two processes above the excavation, one narrow and oblique, the other conical and upright, the two touching at their tips. But the second joint appears of different shape from almost every direction it is viewed from. The tubercle on the front femora of the male is concealed by the overlapping sides of prothorax.

Laius minutus, n.sp. (Plate XXII., Fig. 11.)

♂ Black, in parts with a faint purplish gloss; prothorax somewhat flavous, the apical half, except at sides, stained with brown; elytra with a conspicuous, narrow, raised, median, white fascia not touching suture or sides, but sides at medium third

thickened and flavous; under surface of first and second, and concave upper portion of second joints of antennae, somewhat flavous. With comparatively sparse, but erect dark hairs.

Head longer than usual, moderately convex, with a faint median line. Eyes larger than usual. Antennae rather short. Two basal joints large. *Prothorax* slightly longer than wide; sides somewhat oblique from apex to apical third, thence incurved to base, which is rather narrow. *Elytra* with some small punctures marking off the sutural and lateral thickenings, but elsewhere impunctate, or almost so. Front *tarsi* with the two basal joints apparently conjoined. Length, $2\frac{1}{4}$ mm.

Hab.—Queensland: Dalby (Mrs. F. H. Hobler).

A minute species, not very close to any other known to me, but evidently belonging to Fairmaire's first section of the genus, and allied to *guttulatus;* from the description of which it differs in the median fascia of the elytra not touching the sides, although the sides against which it terminates are pale, but of a decidedly different colour; the apex not spotted, and the tibiae no paler than the femora.

The first joint of the antennae is rather thin at its basal fourth, but thence is rather strongly inflated. The second is about as long as the first, but much wider, convex on its lower surface, and concave on its upper, with the outer margins irregularly folded over the concavity.

Laius alleni, Lea.

On several occasions Mr. Allen wrote to me that he considered this remarkable species to be a carrion beetle; but as no other member of the whole family is known to be such, I concluded that he had confused the species with the common carrion-beetle, *Necrobia rufipes*, a species which in size and colour, except of the legs, it very greatly resembles. Recently, however, Mr. Allen sent nineteen specimens of the species, and wrote of them, "You were dubious about those being carrion-beetles. I have ocular demonstration regarding these specimens, as I caught the bulk of them in head of a fish (severed), lying on the beach, the fish had only been caught that day, and the head was not putrid. I remember now taking the original specimens on rocks, wave-washed, along the sea-beach.

Neocarphurus pilosipennis, n.sp.

♂ Black; head (a spot on forehead excepted), antennae (three or four apical joints excepted), palpi, and extreme base of prothorax flavous; parts of front legs, and sometimes knees of middle

legs, diluted with flavous; eyes green. With a few setae scattered about, more noticeably towards apex of abdomen than elsewhere; elytra in addition with dense and very short pubescence, somewhat similar clothing on abdomen.

Head large; deeply and irregularly excavated; with a large raised space, the front of which is rounded and midway between the antennae, and the hind end of which is notched or foveate, and almost in the exact middle of the head. Antennae extending almost to apex of elytra. *Prothorax* shining; distinctly longer than wide; about once and one-half as long as wide, sides feebly rounded in middle. *Abdomen* suboval, wider than elytra; convex on upper, and concave on lower surface. *Legs* long, basal joint of front tarsi rather large and lop-sided. Length, $2\frac{3}{4}$, to apex of elytra 2, mm.

Hab.—New South Wales: Narromine (E. W. Ferguson).

At first sight apparently belonging to *N. sobrinus*, but elytra with extremely short and depressed, but rather dense pubescence, a character which will readily distinguish it from all others of the genus. In *sobrinus* the cephalic tubercle, when viewed from behind, appears as if with elevated points at each end; in the present species it appears single, and flat-topped, or gently convex. Dr. Ferguson sent seven specimens for examination, but they are all males.

Dasytes blackburni, new name; *helmsi* Blackb., n.pr.

I propose this name as a substitute for *D. helmsi* of Blackburn, *helmsi* having been previously used for a New Zealand species. (Sharp, Trans., Ent., Soc., Lond., 1882, Part 1, p. 66.)

Dasytes julesi, new name; *bourgeoisi*, Lea, n.pr.

I propose this name as a substitute for *D. bourgeoisi*, Lea, as M. Bourgeois informs me that that name had been previously used by Schilsky for a Roumanian insect.

Lampyris australis, Fab.

The type of this species has apparently disappeared. It should be in the Banks' collection, now in the British Museum; but Mr. G. J. Arrow informed me that it was not there now, "and was apparently not there when the collection came to us."

MORDELLIDAE.

Mordellistena longipes, Lea.[1]

This name will stand, as, although it is the same as *jucunda* Champ,[2] that name was previously used for a New Zealand species of *Mordellistena*.[3]

Mordella promiscua, Er.

I have seen the type of this species. It appears to be a small and partially abraded specimen of *communis*, Wath.

CURCULIONIDAE.

Polyphrades biplagiatus, Pasc.

Mr. Arrow confirmed my identification of specimens from King George's Sound as belonging to this species. Mr. Pascoe no doubt wrongly recorded the species from Queensland.

Neosyagrius cordipennis, Lea.

There are eight specimens of this species in the Queensland Museum from Mudgerbah (Queensland). The types were found attacking cultivated ferns; so that a genuine locality record for Australia is of interest.

Atelicus atrophus, Pasc.

There are before me six specimens, that I refer to this species, but no two are exactly alike in size or colour. The type was described as having the middle of the elytra pale, and the posterior declivity with a ring of scales; with these characters a specimen from Mount Wellington agrees, a specimen from Hillgrove (New South Wales) also agrees, but the rest of its surface is much darker than the mountain one. Four other specimens have the derm of the elytra quite uniform in tint, and the club black. Of these one has the apical ring complete but simple; two others have the rings complete, but with inner markings as well, whilst the fourth (from Gippsland), has a complete ring on the declivity of each elytron. This specimen also has a complete median prothoracic stripe. All these specimens have the fifth intestice slightly thickened, and

1. Proc. Linn. Soc. N.S. Wales, 1895, p. 303; described as a *Mordella*.
2. Trans. Ent. Soc. Lond., 1895, p. 272.
3. Broun, Man. of the N.Z. Col., 1880, p. 415.

advanced over the summit of the posterior declivity, so as to appear like a feeble elongated tubercle. The size varies from $4\frac{1}{2}$ to 8 mm.

Atelicus ferrugineus, Waterh.

This species was described originally as from South Australia, but occurs as well in West Australia, Victoria, and New South Wales. The interrupted median line of the prothorax, described by Waterhouse, is not always present. The head is occasionally black. The size varies from 3 to 5 mm.

Atelicus inaequalis, Waterh.

The scales on this species are usually without lustre, but one specimen before me has many scales with a golden glitter.

Misophrice hobleri, Lea.

Some fresh specimens of this species from Mrs. Hobler show an additional range of variation to that of the types. A small specimen measures but $1\frac{3}{4}$ mm. Two specimens have the dark scales on the elytra, not black, but reddish-brown, and covering only about one-third of their surface. The species, however, may be readily distinguished by its long and thin elytral setae.

Thechia alternata, Lea.

This species is without a scutellum, and so should have been referred to *Cenchrena*.[1] I am very doubtful as to whether both *Cenchrena* and *Thechia* will be permanently retained; the presence of a scutellum and the absence (apparent only) of an apical spur to the tibiae are the only distinguishing features of *Thechia*, and these might very well be outweighed by the common triarticulate tarsi.

The types of *alternata* have an indistinct median fascia on the elytra, two other specimens have the fascia rather more defined. The species is evidently, therefore, close to *fasciata*,[2] but differs from the description of that species in having the abdomen uniformly clothed, instead of "in medio argenteo-squamoso."

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1. Pascoe, Journ. Linn. Soc., 1873, p. 24.
2. Pascoe, *l.c.*, p. 24, pl. iii., fig. 9.

Orchestes perpusillus, Pasc. (now *Rhamphus*).

Thinking this species was possibly a *Rhamphus*, I sent specimens that appeared to agree with the description, and were from Champion Bay (the original locality), to Mr. Arrow, of the British Museum. Of them he wrote, "Appears to me to be *Orchestes perpusillus*, Pasc,, from the type. Mr. Guy Marshall agrees with me, and considers it to belong to the genus *Rhamphus*.

Acicnemis spilonota, Pasc. [1]

A specimen from the Endeavour River appears to belong to this species, but differs from the description in having several feeble fascicles at base and apex of prothorax, as well as across middle.

Scolytidae.

Crossotarsus grevilleae, n.sp.

Flavous, in parts dark brown or castaneous. Head, tip of elytra and legs with rather long and sparse pale hairs.

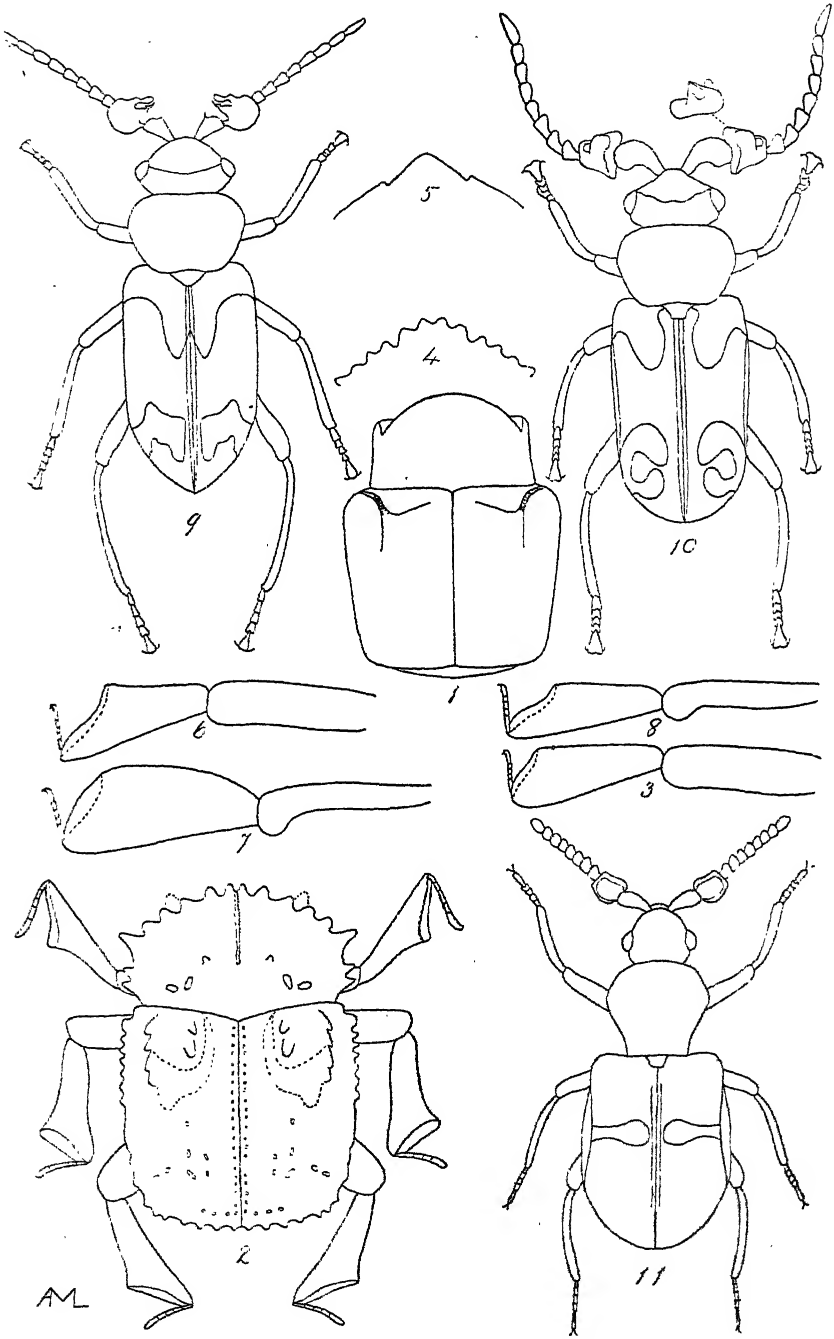
Head flattened in front, and with some distinct but irregularly distributed punctures; base with some small punctures and a feeble median carina. *Prothorax* slightly longer than wide, sides rather strongly incurved near apex, and thence gently inflated to near base; with a few small but rather clearly defined punctures about middle of base. *Elytra* with striae irregularly impressed, deeper about base and towards, (but not at) apex than elsewhere; the interstices with small punctures; suture triangularly notched about apex; extreme apex irregularly vertical, and with several small, conical, seta-tipped projections. Length, 2 mm.

Hab.—Queensland. (C. French, Jr.)

Readily distinguished from all other named species of Australian *Platypides* by its extremely small size. Of the two specimens before me, one has the head, except mouth parts, and pronotum, almost black, its elytra from about the middle are castaneous, but about the apex rapidly become almost black; the other has the dark parts much paler. In both the club is infuscate.

The specimens described, evidently of but one sex, were taken by Mr. French at Melbourne when examining newly imported logs from Queensland of the silky oak (*Grevillea robusta*).

1. Ann. Mus. Civ. Gen., 1885, p. 247.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Coccinellidae.

Chilomenes maculata, F.; *Orcus mollipes*, Oll.

On several occasions I have erroneously referred to this very common and useful West Australian species as *quadripustulatus*, Muls; I have received the correct name from Herr J. Weise.

Cerambycidae.

Xystrocera virescens, Newm.

A specimen of this species was found crushed on a footpath by Mr. P. Lockwood at Launceston, Tasmania. It probably matured in wood brought from Australia.

EXPLANATION OF PLATE XXII.

Fig. 1.—*Pheidoliphila minuta*, Lea.
Fig. 2.—*Chlamydopsis serricollis*, Lea.
Fig. 3.—*Chlamydopsis serricollis*, Lea; hind leg.
Fig. 4.—*Chlamydopsis serricollis*, Lea; front part of prothorax, as viewed obliquely from behind.
Fig. 5.—*Chlamydopsis pygidialis*, Blackb.; front part of prothorax from same position.
Fig. 6.—*Chlamydopsis pygidialis*, Blackb.; hind leg.
Fig. 7.—*Chlamydopsis agilis*, Lea; hind leg.
Fig. 8.—*Chlamydopsis inaequalis*, Blackb.; hind leg.
Fig. 9.—*Laius hackeri*, Lea.
Fig. 10.—*Laius C. purpureus*, Lea.
Fig. 11.—*Laius minutus*, Lea.

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[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. II., 1914].

Art. XVII.—*On Bitter Pit and Sensitivity to Poisons.*

By ALFRED J. EWART, D.Sc.; Ph.D.

(Professor of Botany and Plant Physiology in the University of Melbourne).

[3rd Paper].

(With Plate XXIII.)

[Read 11th September, 1913].

In pursuance of former papers in which the extreme sensitivity of apples to poisons was described, it was thought desirable to obtain a comparison with some other plant structure also capable of prolonged semi-dormant existence. For this purpose potatoes were selected, which, like apples, became discoloured by oxidase action when dead, but which, unlike apples, are capable of further growth, and can, for instance, form cork across a cut surface, which apples can not do.

In addition Rothera and Greenwood[1] have recently attempted to gain direct evidence in regard to the poisoning theory of Bitter Pit, and with negative results. Their works and methods appeared to demand further experimental investigation.

Sensitivity of Potatoes to Poisons.

In order to compare the sensitivity of apples and potatoes to poisons, a number of experiments were performed of which the results are given below. The potatoes were prepared by removing small areas of the skin, and then immersing them in the poisonous solution. They were then cut in two, and the depth to which the brown or purple colour was developed beneath the prepared spots was noted after a few hours' exposure to moist air to allow of the complete oxidation of dead tissues. Snowflake potatoes were used throughout.

MERCURIC CHLORIDE. FIVE DAYS IN ONE LITRE OF SOLUTION, TEMPERATURE AVERAGING 14°C.

Strength of Solution	1 per 1,000.	1 per 10,000.	1 per 100,000.	1 per 1,000,000.	1 per 10,000,000.
Depth of spots.	4–5 mm.	1 m.m.	Superficial browning only.	No distinct signs of poisoning.	No signs of poisoning.

1. Chemical investigation in connection with Bitter Pit, 1913.

COPPER SULPHATE. FIVE DAYS IN ONE LITRE OF SOLUTION, TEMPERATURE AVERAGING 15°C.

Strength of Solution	1 per 100.	1 per 1000.	1 per 10,000.	1 per 100,000.	1 per 1,000,000.
Depth of spots.	5–10 mm.	3–5 mm.	2–3 mm.	Superficial browning only.	No signs of poisoning.

With stronger solutions of copper sulphate, when the potatoes are first cut open, a bluish tinge can be seen beyond the browned areas, but after exposure to air all this region browns, and it consists wholly of dead cells.

With solutions of lead nitrate, 1 per 10,000 strength, a faint superficial browning appears on the prepared spots after five days; but with more dilute solutions (1 per 50,000), no signs of poisoning can be detected.

With strong solutions (1 per 1000 to 1 per 10), the tissues beneath the prepared spots remain white, and at first seem to show no signs of poisoning. After a day's exposure to air, however, greyish, scabby spots 1-2 mm. deep develop with a 1 per 1000 solution, and this tissue is made up of dead cells.

Potato juice produces a white flocculent precipitate with lead nitrate, and this action seems to retard considerably the penetration of the lead nitrate. An excess of the latter apparently destroys the oxidase ferment responsible for browning, and potato slices immersed in 10 per cent. lead nitrate remain white for an indefinite length of time. A lesser strength of lead nitrate is needed to kill the pulp cells than to destroy the oxidase. Hence if potatoes are placed in a 5 per cent. solution, beneath each prepared spot is an area of white but dead tissue, and then a brown zone, in which the lead is less concentrated, and the oxidase has had time to act after the cells were killed. Just in front of the brown zone, a white line can be seen, where the cells have been killed, but where no oxidation has as yet occurred, and further in still the cells are living and normal. (See Plate xxiii.) To produce browning, therefore, a time interval is necessary between the death of the cell and the destruction of the oxidase.

With similar exposures at a temperature averaging 13-14° C., the potatoes showed themselves insensitive to 1 per 100 solutions of magnesium sulphate, and 1 per 2000 solutions of barium chlorate, while only a faint superficial browning was produced by a 1 in 50 solution of magnesium sulphate, and a 1 in 500 solution of barium chlorate.

Solutions of potassium chlorate showed no signs of any poisonous action up to strengths in which a strong osmotic action was exercised. Thus even after five days at 13° C. in a 5 per cent. solution, and in spite of the fact that the prepared spots were slightly depressed owing to the withdrawal of water, no signs of any poisoning action could be seen beyond a faint superficial browning on some, but not all, of the prepared spots.

To test the effect of an acid, sulphuric acid was selected; prepared potatoes immersed in it, and examined after one day in the air.

SULPHURIC ACID, EXPOSURE FIVE DAYS, TEMPERATURE AVERAGING 12-13°C.

1 per 250.	1 per 1000.	1 per 10,000.	1 per 50,000.	1 per 200,000.
Dead tissue 8–10 mm. beneath each prepared spot, but quite white.	Dead tissue 5–6 mm. deep, quite white.	Pits 2 mm. deep, faint brown.	Faint superficial browning.	No signs of poisoning.

Sulphuric acid is feebly acid to litmus paper up to 1 c.c. in 100,000 of water, but shows no perceptible acidity with 1 in 1,000,000. Hence litmus is slightly more sensitive to acid than potatoes are. Using potatoes with small sprouts, the latter were completely destroyed and rotted in concentrations up to 1 in 10,000, with 1 in 50,000 the tips of the sprouts were slightly affected, but a 1 per 200,000 solution did not produce any more effect than immersal in distilled water.

Using caustic potash, prepared snowflake potatoes were immersed for five days at an average temperature of 13° C. in ¼ litre of solution, then cut open along the line of prepared spots, and examined after 2 hours' exposure to air.

CAUSTIC POTASH.

1 gram per 100 c.c. water.	Pits 3-4 mm. dep.
1 gram per 500 c.c. water.	Pits 1-2 mm. dep.
1 gram per 1000 c.c. water.	Pits superficial to 1 mm. deep.
1 gram per 2000 c.c. water.	Faint, superficial browning only.
1 gram per 5000 c.c. water.	No distinct signs of poisoning.

Snowflake potatoes appeared to be comparatively insensitive to anæsthetics. Thus with an immersal of 3 days at 13-14° C. in a 5 per cent. solution of ether, the tissue was killed to a depth of 3-4 mm. beneath the prepared spots, but only browned on exposure to air, presumably owing to the ether retarding oxidase action. With a 1 per cent. solution the tissue was killed on the surface, and hardly browned at all, while no signs of poisoning were shown with a 0.2 per cent. solution.

The influence of temperature. To test the influence of temperature on the sensitivity to poisons, snowflake potatoes were selected, and mercuric chloride used as the poison. After the removal of fragments of the skin around a median line, they were immersed for 3 days in half a litre of solution. After the exposure they were cut in half through this line, and exposed to the air for a couple of hours. At 30° C., even if the liquid is kept well aerated, the immersal cannot be prolonged further, since after the third day the controls in pure water, which previously are unaffected, begin to show signs of asphyxiation, dead, discoloured tissue then appearing, usually first at the centre. In a 1 per 1,000,000 solution at 30° C. bacteria develop rapidly in spite of all precautions, and hence the solution was replaced by fresh sterile solution daily. With the 1 in 10,000 and 1 in 100,000 solution at 30 ° C., most of the pits were pale at the surface, with a curved dark band deeper in, and on exposure to air in most cases a more diffuse and less darkened zone of dead tissue extended a short distance into the pulp beyond this band. With shorter periods of immersal, the poisoning does not extend beyond the dark band.

	Concentration.		
Temperature.	1 per 10,000.	1 per 100,009.	1 per 1,000,000.
29–30°C.	Dark pits 3–5 mm. deep, and tissue dead and darkening nearly to centre.	Pits less dark, 1–3 mm. deep, and diffuse zone beyond darkening to a depth of 2-5 m.m	Slight superficial darkening beneath prepared spots, to a depth of 1 m.m.
13–14°C.	Pits 1–2 m.m deep, but not very dark.	Slight superficial darkening only.	No signs of poisoning.
0–1°C.	Slight superficial darkening and brown rim to prepared spots.	No signs of poisoning.	No signs of poisoning.

SENSITIVITY OF APPLE AND POTATO (Poison Limit at 13–15°C.)

	APPLE.		POTATO (Snowflake.		
	Concentration.	Mol. Eq.	Concentration.	Mol. Eq.	Ratio.
$HgCl_2$	1 per 10,000,000	2710	1 per 100,000	27.1	100
30°C.	1 per 100,000,000	27100	1 per 1,000,000	271.0	100
0–1°C.	1 per 100,000	27	1 per 10,000	2.7	10
$CuSO_4$	1 per 1,000,000	249	1 per 100,000	24.9	10
$Pb2NO_3$	1 per 2,500,000	827	1 per 10,000	3.3	250
$MgSO_4$	1 per 5,000	1.2	1 per 50	0.012	100
$BaCl_2$	1 per 10,000	3.0	1 per 500	0.15	20
H_2SO_4	1 per 1,000,000	53.	1 per 50,000	2.65	20
Alkali	1 per 10,000	0.4	1 per 2,000	0.05	8
KCl	1 per 10,000	0.7	1 per 20	0.0014	500
Anaesthetic	1 per 100,000	11.9	1 per 100	0.0074	1000

In all cases, therefore, apples are much more sensitive to poisons than potatoes. The cells of the latter are undoubtedly more actively living, as is shown by the power of forming cork across a cut surface, which the pulp cells of the apple are unable to do. The latter are adult cells, with only a thin lining layer of living protoplasm, specially adapted for prolonged existence in a more or less statical condition, during which their equilibrium is very easily upset by the merest trace of poison. A high temperature affects the sensitivity of potatoes to poison in the same way as it does apples.

Poisoning Theory of Bitter Pit.

Rothera and Greenwood[1] have recently made an attempt to obtain a direct answer to this problem. They found in the first place that starch grains from both pitted and normal apples would dissolve in diastase, but that in some cases starch grains might still be undissolved after 10 days, thus confirming the results obtained by me in 1912[2], which also showed that resistant grains will usually dissolve after treatment with dilute hydrochloric acid, for a reason to be given later. In regard to the cell-wall, misled by McAlpine's statement (1st Report, p. 12), that the brown colour of bitter pit is due to a gummy or mucilaginous substance of a pectic character, which colours the cell-walls brown, Rothera and Greenwood investigated the chemistry of the cell-wall, and could find no pronounced indication of a difference of composition between the cell-walls of healthy and pitted tissue. This is not surprising, since the brown colour is due to the formation of an oxidation product of tannic acid which unites with the protoplasm lying within the cell-wall. In the early stages of bitter pit the cell-wall is colourless and unaltered. Any changes in the cell-wall could only be the result of slow impregnation subsequent to death.

Direct tests of the poisoning theory of bitter pit were performed by adding the insoluble ash of bitter pit, and the portion dissolving in 10 per cent. nitric acid to starch—diastase solution. No poisoning action could be detected as compared with controls. This is hardly surprising. One experiment only was performed with bitter pit material, which had been mixed with sand, triturated and used for the extracton of starch. It had, therefore, already been washed, and was again well washed with water, alcohol and ether. The possibility of poisons being washed out

1. Chemical investigation on Bitter Pit, 1913.
2. Proc. Roy. Soc. of Victoria, vol. xxiv. (n.s.), p. 416.

by this treatment was overlooked. The bitter pit ash obtained by incineration contained over 70 per cent. of added sand, and the possibility of a formation of insoluble silicates (lead silicate, etc.) needs consideration. Finally, 10 per cent. nitric acid is not a general solvent for metals or metallic oxides, and in insoluble form a poisonous metal is comparatively harmless.

In other experiments the pitted tissue was directly tested by leaving it in contact with diastase solutions for a day, then filtering off and testing the diastase with starch solution. The authors state that the action of malt diastase was strongly accelerated after contact with boiled and unboiled bitter pit pulp, and normal pulp, and that with taka diastase, practically no effect was exercised. On repeating these experiments with filtered solutions of malt diastase dissolved in distilled water, I am able to give them emphatic contradiction. Prolonged contact with pounded apple pulp, boiled[1] or unboiled, bitter pit or normal, practically destroys diastase in 1 to 3 days[2], and unboiled pulp, if anything, appears to be more active than boiled.

Even contact for a short time with pounded apple pulp retards or inhibits diastatic action. Thus (A) 20 grams of pounded apple pulp, and (B) 20 grams previously heated to 100° C. for 15 minutes, were added to separate 10 c.c. of 1 per cent. Taka diastase, and at once filtered. In three hours 5 c.c. of each filtrate were added to 10 c.c. of 0.5 per cent. starch, and a control contained 10 c.c. of 0.5 per cent. starch to 5 c.c. of 0.33 per cent. Taka diastase.

The solutions were kept at 35° C., and portions tested at intervals with iodine. In (A) the liquid was brown, and developed a large, brown coagulum, which was shaken up before testing. In (B) the liquid was colourless, and formed a smaller precipitate, later nearly all dissolving.

	3 Hours.	6 Hours.	16 Hours.	30 Hours.
(A)	Blue.	Blue.	Blue.	Blue.
(B)	Blue.	Purplish blue.	Purple.	Purple.
Control	Paler blue.	Purple.	Nil.	Nil.

On testing (A) and (B) the former contained distinctly more tannic acid. Apparently in the heated pulp a good deal of the tannic acid combines with the coagulated proteids of the cell.

1. Out of contact with water.
2. With prolonged exposure a portion of the action appears to be due to the diastase destroying itself when in solution even at low temperatures such as 14 or 15°C. (See Czapek, Biochemie, vol

The apparent accelerating action on malt diastase observed by Rothera and Greenwood is the result of an experimental error, and is probably due to the action of the tannic acid of the apple pulp upon the starch solution, and upon the iodine test employed.

On mixing 1 per cent. solutions of gallotannic acid and starch a dense white precipitate is thrown down. With more dilute solutions up to 0.1 per cent. a more bulky and gelatinous precipitate forms. A slight gelatinous precipitate may form even when 0.04 per cent. solution is used. These results are shown even when filtered starch solution is used, but the settling of the coagulum or precipitate is slower. The precipitate dissolves on boiling, and is precipitated on cooling, even in the presence of dilute HCl. On repeatedly washing the coagulum with water all the tannic acid can be removed, and it then gives no appreciable blue with ferric chloride. If strong tannic acid is poured into starch solution, pasty masses of plastic starch form. On boiling in water these break up, but without completely dissolving, especially if they have been for some time in contact with the tannic acid. They dissolve, forming a clear solution on warming with dilute hydrochloric acid, but on cooling a white precipitate of starch is formed. The coagulum is not strongly attacked by diastase. At least in experiments lasting over 1-2 days at 30° C., the precipitated starch was still undissolved by 1 per cent. malt diastase, and gave a strong blue with iodine. After drying in air the plastic masses of precipitated starch became hard and translucent. They did not dissolve even on prolonged boiling with water, but dissolved rapidly on the addition of hydrochloric acid, forming a clear solution, giving blue with iodine. This "insoluble" starch is probably in a different physical condition to the starch grains, and appears to be very resistant to diastase.

An excess of cold 2 per cent. tannic acid even precipitates soluble starch, but the milky liquid becomes clear again at 35° C., and cloudy on cooling, while the dried gummy precipitate dissolves readily in boiling water. Gallic acid is much less active than gallotannic acid in precipitating ordinary starch, and has no precipitating action on soluble starch, even in considerable excess. In addition Heintz[1] has shown that tannic acid interferes with the iodine test for starch. Thus, if a drop of iodine solution is added to a mixture of a 1 per cent. tannic acid and 1 per cent. starch solution, the blue rapidly fades to purple, and then

1. Jahresb. Agrikult.-Chem., 1879, p. 499.

colourless. On adding excess of iodine, the blue colour is permanent. As the precipitated starch is allowed to settle, the liquid above gives colour reactions with iodine very like those occurring during diastatic action, and in the presence of tannic acid, a small amount of starch is easily overlooked. This is probably the explanation of the erroneous statement made by Rothera and Greenwood, in regard to the accelerating action of contact with apple pulp, on malt diastase. If 0.5 per cent. solutions of diastase and tannic acid are mixed and filtered, the filtrate throws down a white coagulum with starch solution, which may still be undissolved, even after 3 days.

The retardation of amylolysis by tannin was first shown by Payen, but the action has been considered to be due to the tannic acid precipitating the diastase. (Czapek, Biochemie, vol. 1, p. 344). The following experiments are given in full, since they show the exact action of the tannic acid. Needless to say, before each sample was taken, the liquid was shaken, so that any precipitated starch was evenly distributed, and the proper amount of iodine was used in each case.

Tannic acid produces a bulky white precipitate, with ordinary papain and pepsina porci, but pure pancreatin and diastase remain clear, or shew only a slight cloudiness. By treatment with alcohol, and washing active diastase can be recovered. Gallic acid does not precipitate any of these ferments appreciably, if clear solutions are used, and the amount of precipitate formed with tannic acid appear to depend upon the amount of contamination with foreign coagulable proteids. The action of the tannic acid is on the starch rather than upon the diastase, and hence gallic acid, which is a feebler starch coagulin, affects diastase action less than tannic acid does.

In the first experiment (A) 5 c.c. of unfiltered 1 per cent. diastase was added to each 5 c.c. of filtered 1 per cent. starch solution, and 5 c.c. of the solution of gallotannic acid to each mixture. In experiment (B) filtered 1 per cent. diastase was used, and the temperature kept between 26° and 28° C. Portions of each solution were tested at regular intervals of time with iodine, the colour sequence as the starch dissolves being blue, violet, purple, brown, yellow, the last being merely due to the iodine, and being given as nil.

TABLE A.

Tannic Acid Solution added.	Iodine Test After 3 Hours.	16 Hours.	26 Hours.
5 c.c. of 5%*	Strong blue.	Strong blue.	Starch in dense ppt., liquid starchless.
5 c.c. of 1%	Strong blue.	Strong blue.	Nearly all starch pptd.
5 c.c. of 0.2%	Strong blue.	Strong blue.	Strong blue.
5 c.c. of 0.4%	Paler blue.	Paler blue.	Violet.
5 c.c. of 0.008%	Purple.	Purple.	Nil.
5 c.c. of 0.0016%	Purple.	Nil.	-
5 c.c. of 0.0010%	Nil, all dissolved.	-	
5 c.c. of distilled water	Nil, all dissolved.	Nil.	-
5 c.c. of 1% starch and 10 c.c. of 2.5% tannic acid	Strong blue.	Dense residue of starch; liquid, starch free.	-

*Equalling in the total 15 c.c. of solution, a concentration of 1.6% of tannic acid (⅓ of the concentration of the 5 c.c. added in each case.

TABLE B.

Tannic Acid Solution added.	Iodine Test After 1½ Hours.	3 Hours.	6 Hours.	18 Hours.	30 Hours.
5 c.c. of 1%*	Blue, and white ppt.	Blue.	Blue.	Blue.	Blue.
5 c.c. of 0.2%	Blue, and gelatinous ppt.	Blue.	Blue.	Blue.	Blue.
5 c c. of 0.04%	Blue.	Blue.	Blue.	Blue.	Blue.
5 c.c. of 0.01%	Blue.	Blue.	Blue.	Blue.	Blue.
5 c.c. of 0.005%	Blue.	Blue.	Pale blue	Purple.	Nil.
5 c.c. of 0.001%	Paler blue.	Purple.	Nil.		
5 c.c. distilled water.	Paler blue.	Purple.	Nil.		

*Total concentration one-third of this in each case.

Similar results were obtained with Taka diastase, except that it appeared to be a little less sensitive than the samples of malt diastase used. Possibly on this account the retarding action of the 0.02 per cent. solution was not so pronounced, and it required from 0.2 to 0.08 per cent. solutions to practically arrest the diastatic action. At least much undissolved and condensed starch was still present in the latter case after 30 hours. A portion of the difference was due to the higher temperature, and with malt diastase at 35° C., 0.2 to 0.08 per cent. tannic acid was also necessary to prevent the complete solution of the starch in 30 hours.

To each 5 c.c. of 1 per cent. Taka diastase, and 5 c.c. of 1 per cent. solution, 5 c.c. of tannic acid were added, and the mixture

kept at 35° C., and tested at intervals with drops of iodine solution. With the 1 per cent. and the 0.2 per cent. solutions of tannic acid a large coagulum of starch was formed condensing on standing. With 0.04 per cent. a slight coagulum was formed, later nearly dissolving.

Tannic Acid.	3 Hours.	9 Hours.	20 Hours.	30 Hours.
5 c.c. of 1 %*	Strong blue.	Strong blue.	Strong blue.	Ppt. smaller but giving strong blue.
5 c.c. of 0.2%	Strong blue.	Strong blue.	Strong blue.	Ppt. smaller but giving strong blue.
5 c.c. of 0.04%	Strong blue.	Fairly strong blue.	Purple.	Pale purple.
5 c.c. of 0.02%	Fairly strong blue.	Fairly strong blue.	Pale purple	Nil.
5 c.c. of 0.008%	Paler blue.	Greenish blue.	Nil.	Nil.
5 c.c. of 0.001%	Greenish blue.	Greenish blue.	Nil.	Nil.
5 c.c. of water	Greenish blue.	Purple.	Nil.	Nil.

* Total concentration one-third of this in each case.

There are some indications that even after adding 5 c.c. of 0.2 per cent. tannic acid (making a concentration of 0.07 per cent. approximately in the whole liquid), a small amount of the precipitated starch was converted into sugar at 35° C., and there is slightly less precipitation when the solutions are warmed to 38° C. before mixing them if they are mixed at 14° or 15° C. Accordingly in the following experiment the solutions were all warmed to 38° C. before mixing, and kept at that temperature for 24 hours. Each tube contained 5 c.c. of 1 per cent. starch, 5 c.c. of 1 per cent. diastase, and 5 c.c. of tannic acid. The controls were boiled. The tubes were shaken several times during the 24 hours, and then 10 c.c. of the supernatant liquid tested with Fehling's solution, using an excess of sodium hydrate. The brown precipitate dissolves, forming first a green, and then a brown liquid, and tests showed that even in the presence of tannic acid small quantities of sugar can be detected. Tannic acid itself gives a red precipitate[1] with Fehling's solution, if the sodium hydrate is not in excess. If the latter is in excess the tannic acid reduction is separated by a long interval from the sugar reduction, or is practically arrested. The red precipitates were allowed to settle for not more than 10 or 15 minutes, filtered rapidly on tared filter papers, washed, dried and weighed, and the excess weight over the control is given in the third column of the table.

1. According to Sonnenschein, Ding. Polytechn. Journ., Vol. cclvi., p. 566, 1885, 1 gram CuO= 0.4126 gram tannin and 0.4245 gram dextrose.

Concentration of Tannic Acid in whole solution.		Supernatant liquid.	Reduction to Fehling's test.	Residue.	Iodine Test.
0.33%	Unboiled.	Milky.	Weak. (0.00 gram.)	Small, but condensed.	Strong blue.
	Boiled control.	Very milky.	Weak.*	Small, but condensed.	Strong blue.
0.16%	Unboiled.	Clear.	Slightly stronger. (0.01 gram.)	More bulky.	Strong blue. slightly purplish.
	Boiled control.	Milky.	Weak.	Small, but condensed.	Strong blue.
0.033%	Unboiled.	Clear.	Distinctly stronger. (0.025 gram.)	Smaller.	Strong, but distinctly purplish blue.
	Boiled control.	Milky.	Weak	Still smaller but more condensed.	Strong blue.

*The diastase used gave a faint reduction with Fehling's test.

Even at optimal temperatures therefore tannic acid distinctly retards diastatic action in a concentration of 0.0003 to 0.003 per cent. (only 1-10th of the starch having dissolved), strongly retards it in concentrations of 0.003 to 0.06 (1-25th dissolved) and practically inhibits it in concentrations of 0.33 to 1 per cent.

Tannic acid may therefore be regarded as a "coagulin," or "anti-diastase." Its inhibitory action appears to be much more pronounced at 15-20° C. than at 35° C. and the average temperature at which the metabolism of the apple takes place lies within the former limits. Now, P. R. Scott found the sap of pitted Wolsely apples contained 0.106, and that of clean apples 0.074 of tannic acid per 100 c.c. of juice. At first sight we might seem to have here an explanation of the non-solution of the starch grains in bitter pit.

The resistance of apple diastase to tannic acid has, however, still to be determined. In addition the diastase of the pulp cells is in their protoplasmic lining, whereas the tannic acid is in the cell-sap within. It is only when the protoplasm is killed that tannic acid penetrates it, and there it comes into contact with the oxidase ferment, and is oxidized to a brown colour. The absence of the latter so long as the cell is living shows that the diastase and the oxidase ferments are not in contact with tannic acid, although the vacuolar membrane separating them may represent a space of less than a thousandth part of a millimetre. Further there is no evidence to show that the percentage of tannic acid is higher prior to bitter pit formation, and an increased percentage of tannic acid often follows as the result of injury or stimulation

to a plant tissue without exercising any additional injurious influence.

Any starch grains, however, which were extruded into the cell-sap would be protected from diastatic action, and hence it was of interest to determine their actual position in bitter pit cells, and in those occasional starch-bearing cells, which so frequently occur in healthy pulp tissue. Sections of bitter pit and healthy pulp were stained with iodine, and examined in a horizontal microscope. After noting the position of the starch grains, the stage was rotated through 180°. It is easy to see in this way that certainly 99 per cent. of the starch is in the protoplasm. Very occasionally a large starch grain can be seen to be lying in the vacuole, and to move when the cells are turned upside down. The same is shown in carefully teased preparations. In the brown starch bearing tissue formed by bruising an apple when it is in the starch stage of development, free starch grains lying in the vacuole are much commoner, but even here by far the greater number of the starch grains always remain in the dead protoplasm. Any starch grains lying in the vacuole after prolonged contact with tannic acid would become more resistant to diastatic action. Probably this is the explanation of the occurrence of occasional resistant grains in the starch of both normal and bitter pit pulp. The fact that treatment with dilute hydrochloric acid makes these grains more readily dissolved by diastase is not necessarily due, as I formerly supposed to be the case, to the removal of a poison inhibiting ferment action, but is possibly due to the acid removing the peculiar insoluble or difficultly soluble condition into which contact with tannic acid throws starch.

The Diastase Method of Detecting Poisons.

That this method of detecting extraneous poisons in bitter pit tissue would be a failure might have been predicted from the foregoing facts. Indeed, since metallic poisons usually combine with the proteids of the cell, a cell which had just received enough to poison it might have little or no available surplus to poison a second cell or a solution of diastase.

Cubes of apple pulp weighing 5 grams were floated for two days on (a) water, (b) 1 per 1,000,000 mercuric chloride: (a) browned on the surface, (b) more deeply, and a duller brown. Each was then pounded up, 10 c.c. of 0.05 per cent. diastase added and filtered after each day. 5 c.c. of each filtrate were added to

10 c.c. of dilute 0.05 per cent. starch solution. In the control all the starch dissolved at 35° C. in 3 hours, but even after 1 day abundance of starch was present both in (a) and (b), and a large coagulum separated out containing nearly all the starch. After two days the starch was still undissolved, but more reducing sugar seemed to be present than in the control. The clear liquid turned pale yellow with NaHO , and contained tannic acid derived from the apple sap, but a good deal of the tannic acid combines with the proteids of the tissue, or is carried down by the precipitated starch.

In a similar test there were added to 10 c.c. of 0.5 per cent. diastase and 10 c.c. of 0.5 per cent. starch (a) 10 c.c. of distilled water, (b) 10 c.c. of boiled filtered apple sap, and (c) 10 c.c. of 1 per 1,000,000 $HgCl_2$. Both (a) and (c) remained clear, and the starch dissolved in 3½ hours, whereas in (b) a white coagulum of starch formed which was not entirely undissolved, even after 3 days at 25° C. The clear supernatant liquid before shaking gave no reaction with iodine, just as though all the starch had been dissolved instead of merely the unprecipitated starch.

Similar experiments with equal volumes of solutions of mercuric chloride, 0.2 per cent. malt diastase, and 0.5 per cent. starch, showed that a 1 per 1,000,000 solution of mercuric chloride exercises no appreciable influence upon the diastase, whereas a 1 per 10,000 solution appeared to stop the diastatic action entirely.

The pulp cells of apples are evidently much more sensitive to mercuric chloride than is diastase or diastatic action. In bitter pit formation, however, the arrest of diastatic action comes first, and the death of the cell follows later. The diastase of apples is either small in amount, or feeble in activity, as compared with malt diastase, and the solution of the starch grains in ripening apples may take not a few hours, but several weeks to complete, so that a feeble diastatic activity might be suppressed or retarded by gradually accumulating traces of poison until the concentration was reached at which the protoplasm was killed. Under the conditions of a laboratory experiment where the tests must be completed in a few hours to a day or so, and comparatively large amounts of ferments used, the use of diastase would only detect a poison in the ash of bitter pit tissue when present in relatively large amount. It would not necessarily detect an amount of poison sufficient to inhibit a feeble diastatic activity, taking normally days or weeks to be completed. It is also conceivable that an amount of poison insufficient to inhibit diastatic action, or to

kill the cell might inhibit the production of diastase, and there is some evidence to show that in certain plants (fungi, etc.), not only poisons, but also food substances may exercise a regulatory or inhibitory action upon the formation of diastase. Dr. White, however, found diastase to be present at least in the early stages of bitter pit. As it is not possible to detect metallic poisons in bitter pit tissue by the diastase method, what is needed is a complete exhaustive percentage analysis of the ash of bitter pit tissue, using large quantities of material, and methods of concentration like those which enable traces of certain metals to be extracted from their ores. No such analyses have as yet been made, and they lie more in the province of the chemist than of the plant physiologist, but the significant fact noted by Mr. P. R. Scott, that the percentage of ash is higher in bitter pit tissue than in normal pulp, merits further investigation.

Summary.

In all cases potatoes are less sensitive to poisons than apples, the differences in the resistance varying from 1000 times (anaesthetic), to 8 or 10 times (alkali and copper sulphate). Mercuric chloride and copper sulphate are about equally poisonous to potatoes, and sulphuric acid is only slightly less poisonous than lead nitrate, and is some 50 times as poisonous as is alkali.

As in the case of apples, the sensitivity to poisons is much greater at high than at low temperatures. Tannic acid precipitates starch from its solution in water. The precipitate dissolves on boiling, and forms again on cooling, even in the presence of hydrochloric acid. The precipitate can be obtained in gluten-like masses soluble with difficulty, or imperfectly soluble in diastase, and in hot water, but readily soluble in dilute hydrochloric acid on boiling. The occasional resistant starch grains found in apples have possibly been in contact with the tannic acid of the cell-sap. They will dissolve in diastase after warming with dilute hydrochloric acid, and then washing well.

The presence of 0.0003 to 0.003 per cent. of tannic acid distinctly retards diastatic action; 0.003 to 0.06 per cent. strongly retards it, and 0.33 to 1 per cent. practically inhibits it. This effect is shown at 35° C., and is still more pronounced below 20° C. The cell-sap of apples may contain up to as much as 0.1 per cent. tannic acid, and bitter pit tissue appears to contain more than normal pulp. This will protect any starch grains extruded into the cell-

sap from solution, and in cells bruised while in the starch stage, will aid in preventing the starch from dissolving. In the bitter pit cells, however, the starch grains are in the protoplasm, and so long as the latter is living the tannic acid of the cell-sap is not in contact with them, or with diastase. If any of the tannic is present in the protoplasm, it exists in the form of special small vacuoles, and is also not in contact with the starch or diastase. It is probably the difficulty of penetration which makes externally applied tannic acid non-poisonous in dilutions below 1 per 1000. Diastase solution after prolonged contact with pounded apple pulp loses its solvent action.

In the presence of tannic acid a small quantity of starch is easily overlooked by the iodine test, apart from its precipitation, It was possibly in this way that Rothera and Greenwood obtained an apparent acceleration of diastatic action after contact with apple pulp. Their results are therefore of no value so far as the poisoning theory of bitter pit is concerned. A complete exhaustive numerical analysis of the mineral constituents of bitter pit tissue in bulk is urgently needed, paying special attention to metallic elements present in small amount, and this would probably give definite guidance for further investigation. The nature of the combinations in which the mineral constituents occur will also be of importance. Thus approximately 1 per cent. of the ash may consist of oxide of iron. If this were present, either as the chlorides or sulphates, it would be distinctly poisonous.

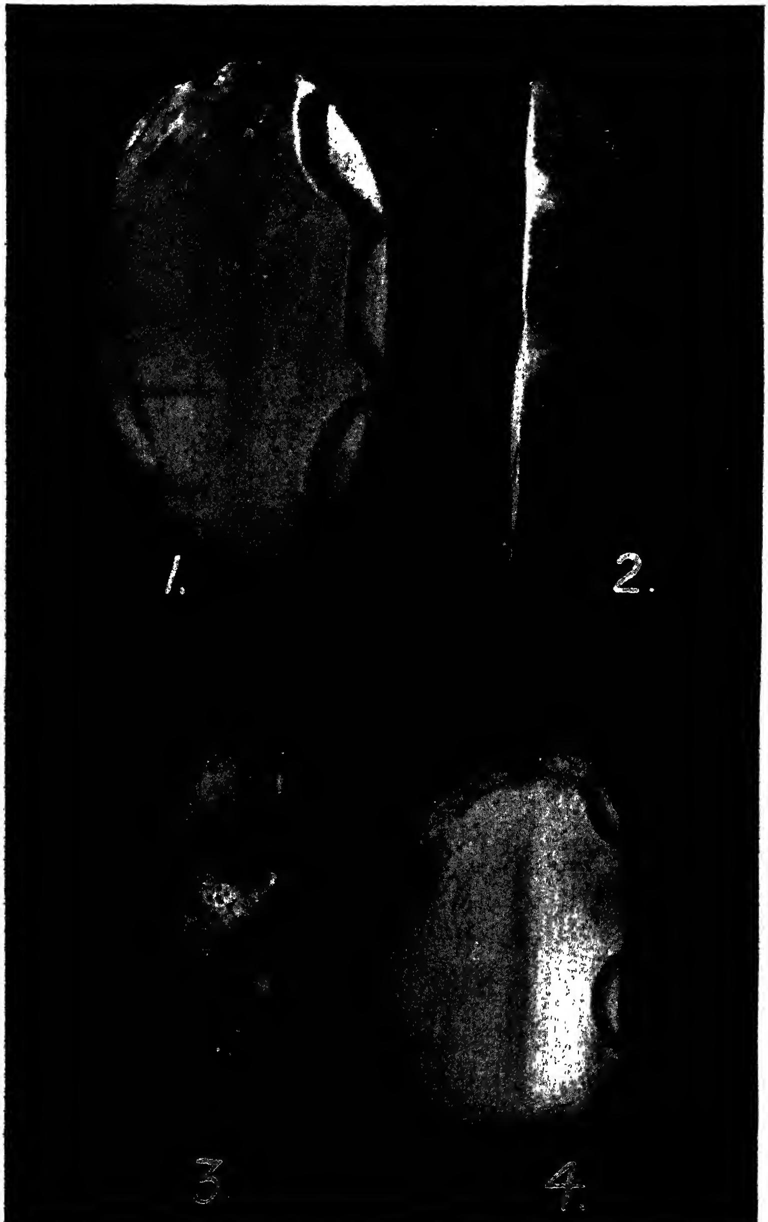
EXPLANATION OF PLATES XXIII.

Potatoes halved after four days in 5 per cent. lead nitrate.

a and d, face view, b and c, side view of cut half.

Two fragments of skin were removed on c and d, and three larger ones on a and b prior to immersal.

The poison was absorbed from the surface, but the browning is deep-seated.


1.
2.
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[Proc. Roy. Soc. Victoria, 26 (N.S.) Pt. II., 1914].

Art. XVIII.—*Notes on Amycterides, with Descriptions of New Species.*

[Part I.]

By EUSTACE W. FERGUSON, M.B., Ch.M.

[Read 9th October, 1913.]

In the present series of papers it is my intention to contribute from time to time such notes on the distribution, relationship and synonymy of the Australian Amycterids as have come to light too late for inclusion in the formal revision now being published in the Proceedings of the Linnean Society of New South Wales. In revising a group so difficult in many ways as the ground weevils, one finds as the work progresses many facts becoming evident which often throw new light on obscure or neglected features in portions of the work already published. Also as it became generally known that I was engaged on the group, collectors from various parts of Australia have sent me specimens for identification; in this way a large amount of material has passed through my hands, and new species have accumulated.

In the present paper appear the descriptions of some new species, belonging chiefly to Psalidura and Talaurinus. I had also hoped to include some notes on the species of Amycterides found in Victoria, but having recently received a good deal more material form Victoria, I have not yet been able to examine it all thoroughly, and must postpone this part of the paper. It may be said, however, that though a good number of species have now been described from Victoria, but little is known about many of them; even some of the commoner species have been only lately described. Of the fauna of many of the mountain ranges of Victoria, the habitat, par excellence, of *Psalidura* and *Talaurinus*, practically nothing is known, and, as species are often strictly local, systematic collecting of the mountain districts will probably bring many new species to light.

Psalidura mira, var. edenensis, n. var.

♂ Of size, form and structure of *mira*, differing in the abdominal fascicles, being broader and more widely separated.

Dimensions.— ♂ 21 x 8 mm.

Hab.—N.S. Wales, Eden (H. J. Carter).

In the position and shape of the fascicles this insect corresponds more with *P. sublaevigata*, but the difference in the prothoracic granules is very marked. *P. mirifica*, which I regard as a variety of *P. mira*, seems intermediate in respect to the fascicles between *mira* and the new variety, otherwise I would have been inclined to regard *edenensis* as worthy of specific rank.

It would be interesting to know whether this species or a closely allied one extended into Victoria. *P. mira* with its varieties ranges from Sydney to Eden, and does probably extend into the north-east corner of Victoria. The only other species of the "horned-jaw" group found in Victoria is *P. approximata*, which occurs at Buffalo Mountains; but *P. carteri*, which is found at Mt. Kosciusko, might also occur in Victoria.

Psalidura taylori, n. sp.

♂ Size small, elongate, subparallel. Black, opaque; sparsely clothed with minute brownish scales; setae black, fascicles reddish, anal hair black.

Head convex, rather densely clothed. Rostrum distinctly separate from head, somewhat dilatate on sides beyond external ridges, internal ridges subparallel, little convergent, medium notch wide, lateral sulci long, deep. Eyes ovate. Prothorax (5 x 5 mm.) widely dilatate on sides, apical margin with median lobe strongly produced and ocular lobes definite, collar constriction well marked, disc depressed in centre, median line evident; closely set with very small depressed granules each bearing a long seta. Elytra (8.5 x 6 mm.) evenly, rather strongly, widened from behind shoulders, base moderately arcuate, humeri definite, not greatly produced; disc with rows of small foveiform punctures, interstices first, third, fifth and seventh prominent, costiform, setigerous in double series; second, fourth and sixth not raised, sparingly setigerous in single series. Metasternum with feeble central impression. Apical segment excavate, preanal fossa deep, occupying most of excavation; fascicles widely separated (2 mm.), posterior edge with dense fringe of short, stout hair. Forceps short, stumpy, apices not meeting, directed backwards, a short knob-like projection present on inner and anterior aspect concealing the small laminae; apical tergite strongly bearded between ends of forceps.

♀ Of a short, obtuse form; protohrax (4.5 x 5.5 mm.) abraded in middle; elytra (11.5 x 8 mm.) with interstices second, fourth and sixth more definitely raised, subcostate, not as prominent as rest. Beneath convex, without excavation.

Dimensions.— ♂ 15 x 6 mm.; ♀ 16 x 8 mm.

Hab.—N.S. Wales, Guy Fawkes (F. H. Taylor); Guyra (H. J Carter).

The Guyra specimens differ in being larger (17 x 7 mm.) and in having the alternate interstices, second, fourth and sixth, more raised. (18 x 8 mm.) less obese, the prothora less abraded.

From the dilatate prothorax and the form of the anal excavation and forceps I regard this species as allied to *P. sulcipennis*, but the elytral interstices would indicate an approach to the groups with all the interstices complete.

Is is a very distinct species, and I have much pleasure in dedicating it to the original discoverer—Mr. F. H. Taylor.

PSALIDURA IRRASA, n. sp.

♂ Black, with muddy scales in depressions; setae light brown, where present moderately long, mostly appearing as if abraded.

Head and rostrum as in *P. variolosa.* Prothorax (5.5 x 6 mm.) strongly dilatate on sides, apical lobe strongly produced over head, discal impression faint; set with small, round, depressed granules, as if abraded, punctures small, setae absent except near sides. Elytra (11 x 8 mm.) with rows of shallow transverse foveae, ridges between not greatly raised, setigerous, not granulate; interstices finely granulate, the granules round, smooth on top as if abraded, the puncture small, occluded, not umbilicate, towards sides and on declivity granules less abraded, setigerous, umbilicate, second, fourth and sixth interstices in single, third, fifth and seventh in double series; sides with rounded setigerous, non-umbilicated granules. Anal excavation wide and deep as in *variolosa*, fascicles closer and longer; posterior edge strongly bearded with black hair extending across middle, intermedite row of hair black, set close against posterior row, differently directed—back and down—apparently not extending across middle line. Forceps short, apicus meeting, laminae obliquely set.

Dimensions.— ♂ 17 x 8 mm.

Hab.—Howell (J. F. Stephen, per H. J. Carter).

Close to *variolosa*, but differentiated by the character of the granules, and by the hair or bristles of the posterior row extending across the middle line. The anal characters are hard to make out definitely, but I have not ventured to dissect out my only specimen.

PSALIDURA INTERMEDIA, n. sp.

♂ Of size and general form of *variolosa.* Black, sparsely clothed with feeble greyish scales; setae long, dark brown. Fascicles red; anal hair black and reddish.

Head and rostrum as in *variolosa.* Prothorax (5 x 6 mm.) ampliate, median lobe strongly produced, collar impression feebly marked, closely set with small, round, strongly setigerous granules, not abraded nor umbilicate, rather smaller in centre. Elytra (10.5 x 7.5 mm.) with rows of shallow transverse foveae, intervening ridges feebly granulate, setigerous; interstices with rounded, strongly umbilicate, setigerous granules, those nearer base feebly flattened, in single series on second, fourth and sixth, tending to duplication in centre, in double series on third, fifth and seventh. Sides with setigerous non-umbilicate granules. Anal excavation wide and deep; fascicles large, closer together than in *wilcoxi;* posterior edge strongly beaded with dark hair or bristles, extending across middle line, intermediate row of a bright red colour, set farther away from posterior row than in *variolosa*, and continued across middle line; apical tergite bearded. Forceps short, apices acute, touching; laminae obliquely set.

♀ Like *variolosa*, (♀).

Dimensions.— ♂ 17 x 7.5 mm.; ♀ 19 x 8 mm.

Hab.—Queensland, Stanthorpe, Dalveen (H. J. Carter and T. G. Sloane).

The arrangement of the anal hair is a bit difficult to make out, the intermediate row appears to be directed inwards and somewhat forwards until on a level with the fascicles on each side, thence the bristles are continued in an arc parallel with the posterior edge, and continuous across the middle line. It seems closest to *P. wilcoxi*, but is a larger species, in general appearance more resembling *P. variolosa.* The distinctions between the species of the *P. wilcoxi* group may be tabulated as follows:—

60 (63) Elytral interstices finely and distinctly granulate.
61 (62) Supranumary tufts (intermediate row) reddish.
a. Intermediate row not continued across middle line. *P. wilcoxi*, Macl.
aa. Bristles continued across middle line. *P. intermedia*, n.sp.
62 (61) Intermediate row of bristles black.
b. Posterior row of bristles not continuous across middle line. *P. variolosa*, Ferg.
bb. Posterior row continuous across middle line. *P. irrasa*, n.sp.
63 (60) Elytral interstices costate. *P. breviformis*, Ferg.

PSALIDURA HELMSI, n. sp.

♂ Elliptical elongate, size large. Black, opaque; in depressions with sparse, muddy clothing; setae moderately long, dark-brown, almost black; fascicles reddish.

Head convex, rather closely setigero-punctate. Rostrum as in *P. monticola*. Prothorax (6 x 6.5 mm.) rotundate, median lobe well defined, collar constriction and median line faint but traceable; closely set with small, round, setigerous granules, rather finer in centre; sides granulate. Elytra (14 x 8.5 mm.) gently widened on sides from behind shoulders to beyond middle, apex somewhat abruptly rounded, mucronate, base widely, not deeply, arcuate; humeral angles out-turned noduliform; with rows of small transverse closely-placed foveae, intrastrial rides setigerous, hardly granulate; interstices somewhat raised, fourth rather less so, all continuous throughout, set with small black strongly setigerous granules in double series, single on portion of fourth. Metasternum widely concave, sides almost on level with middle coxae; anal excavation deep, wide, reaching to anterior margin, preanal fossa hidden with forceps in position; fascicles small, moderately separated. Forceps short, apices obtuse, hardly meeting; laminae slightly bent inwards, apices meeting, broad at base, anterior and posterior edges straight and parallel for about two-thirds of length, thence posterior edge changing direction backwards as well as downwards, and anterior edge continued back to form an obtusely pointed apex. Apical tergite strongly bearded.

♀ Differs in usual manner; fifth segment with feeble median longitudinal impression, sublaevigate.

Dimensions.— ♂ 21 x 8.5 mm; ♀ 21 x 8.5 mm.

Hab.—Victoria, Benalla (R. Helms); National Museum, Melbourne.

In general appearance close to *P. monticola*, but separated by the form of the laminae. In *monticola* the edges of these are subparallel throughout and the apex broadly rounded; in *mirabunda* form of the laminae. In *monticola* the edges of these are subtriangle.

I have much pleasure in dedicating this new species to Mr. R. Helms, who kindly placed him specimens at my disposal.

TALAURINUS CONFUSUS, n. sp.

♂ Of a narrow, elongate form. Black, with evidence of fairly dense greyish subpubescence in parts, this mainly removed from dorsal surface of elytra. Setae light brown in colour.

Head separately convex from rostrum. Rostrum flattened above, the median area and sublateral sulci but little depressed; a deep semicircular sulcus behind apical plate; external margin of dorsum presenting a thin edge, not raised into a ridge, with a feeble sinuation concave outwards in front of base; internal ridges strongly raised above general surface, long, convergent, but not meeting, median area feebly depressed between the ridges, with a short, ill-defined median carina in front. Scrobes looking somewhat upward as well as out, posteriorly widened, but not reaching eye. Scape long, moderately thickened. Prothorax (3.5 x 4.5 mm.) evenly, moderately strongly rounded on sides, ocular lobes feeble, disc with ill-defined subapicial constriction; set with moderately large, contiguous, rounded granules, somewhat irregular in size, each bearing a long seta and tending to leave median and sublateral lines free from granules. Elytra (10 x 5.5 mm.) elongate, little widened posteriorly, base feebly arcuate, humeri evident but not produced. Disc with rows of small open foveiform punctures, each subtended by a single seta; interstices definitely though not greatly raised, set with small subobsolete granules in single series, setae long, directed backwards, the whole sculpture somewhat confused. Beneath with small scattered setae, no median vitta; intermediate segments moderately long, fifth segment not excavate, with narrow transverse sulcus at extreme apex, not extending the width of segment. Legs simple, femora not ridged beneath.

♀ Similar but more robust, fifth segment with shallow oval impression near apex.

Dimensions.— ♂ 15 x 5.5 mm.; ♀ 17 x 7.5 mm.

Hab.—N.S. Wales, Garah (S. D. Webb), Moree (A. M. Lea), Narrabri (F. Musgrave).

A distinct species, not close to any previously described. In general appearance it resembles *T. strangulatus*, Blackb., but that species has a differently sculptured rostrum. In all the specimens in my collection the clothing is reduced to small patches on sides and declivity, but specimens in Mr. Lea's collection have the whole surface almost densely clothed.

I cannot at present state its true position in the genus, the number of granulate forms discovered since my table was published suggest that the grouping suggested therein requires modification. At present, and until material is available from the more inland parts of Australia, particularly S.W. Queensland, I think it inadvisable to attempt such revision. In the characters of the rostrum this species suggests a relationship to *T. variegatus*, Macl., which is found in similar country.

Talaurinus alaticornis, n. sp.

♂ Small, elongate, subparallel. Black, densely clothed with grey and silvery subsetose pubescence (hardly scales), the prothorax trivittate, the elytra obscurely maculate; the head densely clothed with yellow. Setae light brown.

Head convex, separately so from rostrum, forehead obliquely rugulose on each side near base of rostrum; external rostral ridges not raised, the margins of dorsum divergent posteriorly with feebly sinuous outline; internal ridges prominent, little convergent, obliquely rugulosely punctate; median area moderately depressed between internal ridges, the middle feebly raised and subcarinate Scrobes rather strongly curved. Antennae with scape rather short, strongly and sinuously curved backwards, incrassate and dilatate towards extremity, the innermost portion narrow, forming short peduncle. Prothorax (3.5 x 4.5 mm.) moderately and evenly rounded on sides, apical margin rather feebly produced above, ocular lobes feeble; disc closely set with small depressed setigerous granules, for the most part rounded, but in the baso-lateral quadrants of disc showing feeble tendency to run in transversely curved rows. Elytra (8 x 5 mm.) elongate, little widened, base feebly arcuate, humeri marked, slightly advanced; with rows of small shallow transverse foveae obscured by clothing, alternate interstices slightly raised, feebly granulate but strongly setigerous in single series, occasionally duplicated, second and fourth interstices not raised, marked by feeble row of setae. Beneath without median vitta, with obsolete scattered setigerous punctures, fifth segment depressed in middle two-fourths, the depression bounded on each side by a strong carina extending from the anterior margin a little more than half the length of the segment. Legs simple.

♀ Similar to ♂, but more ovate in outline, transverse arrangement of prothoracic granules more evident, beneath gently convex, without depression on fifth segment.

Dimensions.—♂ 13 x 5; ♀ 12 x 4.5 mm.

Hab.—N.S. Wales, Garah (S. D. Webb), Moree (A. M. Lea); S. Queensland, Darling Downs (Lau.).

Closely allied to *T. clavicornis*, but readily distinguished by the prothoracic granules smaller, not flattened or tessellated as in that species.

Talaurinus vitticollis, n. sp.

♀ General facies that of *T. griseus*, Macl. Black, opaque; rather sparsely clothed with exceedingly minute, dark subsetose

scales, with longer white subsetose pubescence forming three longitudinal vittae on prothorax (the middle one only evident at base), an interrupted line along edge of elytra, and fairly densely distributed on legs, with yellow subpubescence at sides of prothorax and elytra, on sterna and abdominal segments, forming a yellow patch in middle and at each side of segments, these being united along the top of each segment. Setae black.

Head continuous above with rostrum, densely clothed except along narrow median line, with scattered decumbent setae. Rostrum excavate, median area depressed, sulcate at bottom; external ridges somewhat convergent, width across base of ridges much less than width of rostrum; internal ridges moderately long, slightly convergent. Scrobes simple, widely open posteriorly. Scape moderately long and robust. Eyes subovate. Prothorax (3 x 4 mm.) subcylindrical, very little widened, apical margin feebly sinuate; disc with fairly definite subapical constriction and moderately impressed median line; with small, not very prominent granules somewhat irregularly disposed, with slight tendency to run together, granules more distinct on sides. Elytra (10 x 6.5 mm.) strongly widened on sides, apex moderately strongly produced, base gently arcuate, humeri marked but not produced; with rows of obscure punctures, the first, third and fifth interstices feebly raised, the others not at all, with no evident granules, but with numerous fine setae more or less irregularly disposed in double or triple series on raised interstices, the whole sculpture obscure and indefinite. more obscure, beneath convex without impressions.

Dimensions.— ♀ 15.5 x 6.5 mm.

Hab.—S. Queensland, Brisbane, Stradbrooke Island (Queensland Museum and R. Illidge).

A typical member of Group IV., second portion of group with humeral angles not produced; it differs from all in the clothing and more obscure sculpture, its nearest ally being *T. griseus.* The elytral sculpture is very indefinite, the rows of depressions, which are more of the nature of shallow foveae, being very hard to trace; the arrangement of the fine setae is also confused. I have not seen a male, but in the allied species, *T. griseus*, the difference in sex is not marked.

TALAURINUS ANGUSTUS, n. sp.

♂ Form elongate, narrow. Black, rather densely clothed with minute muddy subsetose scales; beneath with median yellow vitta; setae dark brown.

Head continuous with rostrum in same plane above, densely clothed and with numerous stout decumbent setae. Rostrum moderately long, little excavate except at apex, the median area narrow, rather strongly depressed, external ridges parallel, internal long, prominent, though less so than external, rather feebly convergent, sublateral sulci long. Scrobes open posteriorly, extending not quite to eye. Eyes ovate. Prothorax (3 x 4 mm.) evenly rounded, but not greatly ampliate on sides, apical margin with rather strongly marked postocular sinuation; closely set with fine, somewhat depressed granules, becoming obsolescent along middle line, sides granulate. Elytra (10 x 5.5 mm.) elongate, not greatly ampliate on sides, base subtruncate, humeri hardly marked. Disc with series of small, practically obsolete punctures closely set; sutural interstice rather feebly raised, stronger at base, with obsolete granules, second with five or six small separate tubercles, obsolescent anteriorly, more evident and subconical on declivity, extending to apex, fourth with none or single one near middle, third and fifth each with a continuous row of small tubercles, obsolete and tending to run together anteriorly, becoming more marked and subconical posteriorly, sixth with row of about six subconical, moderately closely set, not reaching base or apex. Sides with rows of obsolete punctures, interstices not tuberculate. Beneath flattened, intermediate segments rather long, fifth with obscure mesial depression. Anterior femora not rigid. ♀ Similar to male, but more ovate in outline, median ventral vitta less marked, sculpture more obscure, beneath convex without impressions.

Dimensions.— ♂ 15 x 5.5 mm.; ♀ 14 x 5 mm.

Hab.—Victoria, Glenample (T. G. Sloane). Other specimens without exact locality.

In my table of the genus would be placed in group VIII., and with *T. sobrinus*, from which it differs inter alia in shape, tubercles and under-surface. It is perhaps most nearly allied to *T. bucephalus*, but the anterior femora are not rigid beneath, and it is a smaller, narrower and much more obscure-looking species. Although apparently common in Victoria, this species seems to have been previously overlooked.

Talaurinus turneri, n. sp.

♂ Oblongate-ovate, convex. Black, practically without clothing except a small patch of setose pubescence in the middle of each of the two first abdominal segments; setae black, minute, for the most part abraded.

Head strongly convex, rather feebly depressed in front; with a few obsolete punctures. Rostrum short, excavate, external ridges rounded across, subrugosely punctate, somewhat convergent posteriorly; internal ridges prominent, convergent; median area strongly depressed, sublateral sulci long, deep, connected at base by transvere basal sulcus. Sulci well defined posteriorly; eyes ovate. Prothorax (4.5 x 5.5 mm.) rather strongly dilatate on sides, apex somewhat produced above, ocular lobes feeble; disc with bread, shallow subapical transverse impression, median line traceable; closely set with numerous small granules feebly depressed above, as if slightly abraded. Elytra (9.5 x 7.5 mm.) rather widely dilatate posteriorly, apex strongly and abruptly rounded, base feebly arcuate, angles marked but not produced; with rather deep longitudinal striae formed of small closely set transverse foveae, the intervening ridges depressed, but running up on to the interstice on either side; interstices strongly raised, the second the most prominent, the first, second and third definitely costiform, the component granules abraded to base level, the remaining interstices not so evidently costiform, the granules, though showing a tendency towards abrasion, small and distinct, on the fifth and sixth in double series. Beneath, intermediate segments short; fifth with extensive shallow depression reaching to anterior margin in middle and extending to postero-lateral angles, also with a deep, slightly transversely oval median fossa situated near posterior margin, a blunt tubercle present at each side of, and propecting into, fossa, situated a little nearer posterior than anterior margin, and nearer to side than to corresponding tubercle. Anterior femora not ridged, tibiae simple.

Dimensions.— ♂ 15 x 7.5 mm.

Hab.—N.S. Wales, Mt. Kosciusko, 6000 ft., 5th March, 1912.

For the opportunity of describing this species I am indebted to Dr. A. Jeffries Turner, who took the unique specimen on Mt. Kosciusko in March, 1912.

The species forms an interesting addition to the morbillosus group, group xiii. of my revision. From the other members it is readily distinguished by the costiform character of its elytral sculpture. In my table it might be placed next *T. melancholicus*, Lea, and the table would then read :—

116 (111) Third elytral interstice costiform.
a. Second and fourth interstices obsolete.
T. melancholicus, Lea.
aa. All interstices strongly developed.
T. turneri, n.sp.

Though I have placed this group among the tuberculate species, it is evidently not much at home there, both this species and *melancholicus* being strongly costate species, and yet they cannot be separated from their congeners of the same group.

The distribution of these two species, one found at Mt. Kosciusko, the other extending from Mt. Macedon into S. Australia, would suggest the possibility of other forms occurring in the intervening area.

TALAURINUS CARINATUS, n. sp.

♂. Closely resembling *T. costipennis;* elongate, ovate. Black subnitid, practically without clothing above, a small patch of yellow scales in middle of each ventral segment.

Head convex, external rostral ridges continued back into head, forehead somewhat concave between the ridges. Rostrum narrow, internal ridges long, rather feebly convergent, sublateral sulci and median area narrowly and deeply depressed, rostrum deeply excavate in front. Eyes subrotundate. Scape moderately long, strongly incrassate, scrobes simple, not quite reaching eyes. Prothorax (3.5 x 4 mm.) gently rounded on sides, apical margin truncate above, postocular sinuation strongly marked; disc with minute granules closely set, smaller and more depressed than in *costipennis;* sides with similar granules. Elytra (10 x 6 mm.) moderately strongly dilate on sides, apex moderately produced mucronate, base rather feebly arcuate, humeri thickened, somewhat noduliform, not greatly produced. Disc with rows of subquadrate foveae becoming smaller and less distinct posteriorly, arranged in double rows, the second and fourth interstices being absent, outer row in single series, the sixth interstice present; interstices one and three costiform, three particularly prominent and carinate, five costiform showing evidences of granularity, sixth interstice with similar but more evident granularity; sides with irregular punctiform foveae, interstices granulate. Beneath concavo-convex, apical segment with shallow, ill-defined subquadrate impression occupying middle two-fourths. Legs simple, femora not ridged or dentate. ♀ Rather larger and more obese, prothorax (4 x 4.5 mm.) and elytra (10 x 6.5 mm.) with similar sculpture, the fifth elytral interstice showing a greater tendency to granularity. Beneath convex, fifth segment with shallow rounded impression at apex.

Dimensions.—♂ 15 x 6 mm.; ♀ 16 x 6.5 mm.

Hab.—Victoria, Portland (J. Dixon), Nelson (Blackburn). Type in author's collection.

Closely allied to *T. costipennis*, and with similar minutely granulate prothorax, but with different elytral foveae. These are arranged as in *T. costipennis*, in two double rows and one single row, the second and fourth interstices, but not the sixth, being absent. In the rugifer group all these three interstices are absent, and there are in consequence three double rows of foveae, the lateral boundary being formed by the seventh interstice and not by the sixth, as in *carinatus* and *costipennis*. The foveae approach somewhat to the *laevicollis* type, but are not so large nor so clearly defined as in that species; in the median striae they are subquadrate, and while well defined above and below, are less definitely separated laterally from the adjacent foveae in the same stria; in the more lateral rows and posteriorly they are smaller and less defined. I am indebted to Mr. J. Dixon for my specimens of this interesting species. So far as I have seen the costate group does not extend farther to the west than the habitat of this species.

SCLERORINUS AMYCTEROIDES, n. sp.

♂ Elongate ovate, moderately robust. Black, subopaque, rather densely clothed with minute dull golden squamose scales, lower margins with white scales, with strong black median ventral vitta; setae black.

Head continued into rostrum in same plane above, forehead bounded on either side by the continuation back of the external rostral ridges, feebly convex in middle, moderately strongly impressed on either side of convexity, these impressions continuous with basal sulci of rostrum. Rostrum short, external ridges subparallel, plane in profile, continued into forehead, the point of junction marked by a feeble constriction; median area feebly carinate, lateral sulci shallow, only marked, foveiform, at base. Scrobes deep, ending distant to eye. Eyes oval. Prothorax (4 x 5 mm.) rather strongly ampliate, apical margin feebly trisinuate, ocular lobes moderately marked, subapical impression most marked near sides, median and sublateral lines not impressed, but with rather fewer tubercles; disc with moderately large, rounded tubercles, not closely set, except at lateral margins; sides with tubercles obsolescent, not extending to coxae. Elytra (10 x 6 mm.) rather strongly widened on sides, apex abruptly rounded, almost rectangular, base gently arcuate, humeri not produced, with outwardly directed tubercle; disc with strial punctures obsolete, striae indicated by small setigerous granules; sutural interstice with fine

granules, stronger at base, second interstice not raised, with three or four isolated, widely separated subconical tubercles, third interstices tending to converge on declivity, with closely placed transverse tubercles occupying the width of the interstice, sixteen to eighteen in number, stronger and almost imbricate posteriorly, ending half way down declivity, fourth not raised, without tubercles, fifth with nine or ten tubercles similar to those on third, extending from humeri to beyond middle, sixth with five more isolated subconical tubercles extending from in front of middle half-way down declivity. Sides with tubercles flattened, not raised. Ventral segments concave on either side of median hirsute vitta, concavity most strongly marked and forming deep depression on fifth segment. Femora not ridged, tibiae simple.

♀ Closely resembling ♂ in general appearance, elytra more evenly rounded on sides, apex rather strongly emarginate, with dentiform projection on either side at level of third interstice, tubercles slightly more numerous and rather more strongly transverse; beneath gently convex, intermediate segments with faint indications of a median vitta, segments longitudinally scarred or impressed, apical segment with an oval depression at apex.

Dimensions.— ♂ 16 x 6 mm.; ♀ 17 x 7 mm.

Hab.—Victoria, Portland (T. G. Sloane and J. Dixon).

Another female measures 19 x 8 mm.

A thoroughly distinct species belonging to the sabulosus group, bot not close to any other known to me. A superficial resemblance to the genus *Amycterus* has suggested its specific name.

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Art. XIX.—*On the Origin and Relationship of some Victorian Igneous Rocks.*

By H. S. SUMMERS, D.Sc.

(Lecturer and Demonstrator in Geology, University of Melbourne).

[Read 9th October. 1913].

Contents.

I. Introduction.

During the past several years I have been engaged in conjunction with Professor Skeats in making a careful study of the igneous rocks of the Macedon District. An account of our work in this area has recently been published as a Bulletin of the Geological Survey of Victoria (19), but since that paper went to the press I have continued to work on the question of relationship and differentiation of the two igneous series which are so well developed in the neighbourhood of Macedon and Woodend. This has led on to the study of the relationship of the Macedon dacites and granodiorites to rocks of other areas in Victoria, and the evidence that has been collected seems to have considerable bearing on certain aspects of modern petrology.

The most important point to be raised is the relationship of the so-called alkaline and sub-alkaline or calcic groups of rocks to one another. Harker (4) believes that these two branches of igneous rocks are quite distinct from one another, and that the former

branch is fundamentally associated with tectonic movements characteristic of the Atlantic coast type, and the latter is associated with the Pacific coast type of earth movements. Evidence will be advanced in opposition to this belief, and to show that in Victoria the non-calcic granites are genetically related to the calcic dacites and granodiorites.

Professor Skeats and the author have already expressed the belief that the alkaline rocks of the Macedon District represent a fractional differentiation product from the calcic basalt magma.

If these two contentions be upheld, then it follows that the correlation of alkaline rocks with subsidence due to faulting and the correlation of calcic rocks with folding, due to lateral compression, is open to grave objection.

The differentiation of rock magmas will be discussed at some length, but more with the view of determining the relationships of the end products to one another than to attempt any explanation of the means whereby these end products are derived from the parent magma.

II. Victorian Igneous Rocks.

(a) *The Macedon Granodiorite-dacite Series.*

In the Macedon District there are extensive developments of rocks belonging to two very distinct cycles of igneous activity. The older of these series has been shown (19) to consist of dacites, granodiorites and granodiorite porphyries. The dacites were in part extrusive and in part intrusive, and were closely followed by the intrusion of the granodiorites and granodiorite porphyries. It is quite impossible to definitely fix the age of these rocks, as they were intruded through and into rocks of Ordovician age, and are overlain in part by sands and lavas of Kainozoic age. However, for reason given elsewhere it is highly probable that these rocks are of Devonian age.

(b) *Victorian Upper Palaeozoic Series.*

Dacites similar in every respect to those of the Macedon District occur in the Dandenong Ranges and in the neighbourhood of Healesville. Mineralogically and texturally these dacites are entirely comparable with those of Macedon. Phenocrypts of plagioclase, hypersthene, biotite, and occasionally quartz, are set in a granulitic groundmass consisting mainly of quartz and felspar, with some biotite, ilmenite and minor accessories. Naturally there are textural variations, but the above brief description can be applied to the majority of sections examined from Macedon, Dandenong Ranges and Healesville.

Northward from Healesville in the Cerberean Range, and in the northern portion of the Strathbogie Range, a rather coarser rock is the prevailing type. Taking the occurrence at the road-metal quarry at Violet Town as a type of the Strathbogie rocks, the following brief description may be given here.

This rock consists of phenocrysts of plagioclase (acid labradorite), abundant biotite, sparing hypersthene with a moderable amount of quartz in a granulitic groundmass similar in every respect to that described above as occurring in the dacite, except that it is somewhat coarser in grain. The phenocrysts are distinctly larger than those found in the dacite, and there is a larger amount of free quartz present. Garnets are not uncommon throughout this area. An analysis of the material from the Violet Town quarry was made a few years ago for me by Mr. G. Ampt, but has so far not been published. This analysis, which is given later, compares fairly closely with those of the dacites, but as was expected from the microscopical examination, it shows a decidedly higher percentage of silica.

The chemical and mineralogical characters of this rock are sufficiently closely allied to those of the Macedon dacites to cause us to regard them as genetically related to one another.

The southern portion of the Strathbogie Ranges consists of a granitic rock which provisionally may be referred to as adamellite. Frequently there is no hard and fast line of demarkation between the quartz-porphyrite of the northern portion and the adamellite of the southern. To the southward the quartz porphyrite becomes much coarser in grain, and might well be described as adamellite porphyry, and in places passes imperceptibly into adamellite. Near Euroa the junction is more marked, as a fairly broad area of even-grained aplite is found separating the adamellite porphyry from the adamellite. An examination of the junction of this aplitic rock with the porphyry shows that the aplite is intrusive into the latter, as veins from the former can easily be traced running out from the main mass into the adjoining porphyry. The relations of the aplite to the adamellite are not so clear, but apparently the aplite is also intrusive into the adamellite. The inference I make from a study of this field is that the quartz porphyrite and adamellite porphyry are the older rocks, and that as in the case of the Macedon and other dacite areas, the granitic rock was subsequently intruded. The difference noted between the contact in the dacite areas and in this area may be due to the fact that the dacite was largely effusive, whereas the field evidence and microscopical

character of the northern Strathbogie rocks tends to show that they were entirely intrusive in character. One might picture first an intrusion of the porphyry, followed at a short interval by a more deep-seated intrusion of adamellite. Subsequent cooling and contraction left an opening at the junction for the intrusion of the still molten, somewhat more acid residuum. Except for a slight schistocity there is very little evidence of contact metamorphism in the porphyry, such as has been noted at Macedon, Belgrave and elsewhere in the dacite. This might be explained by the fact that the temperature of the aplite at its intrusion would be relatively low, and the resultant metamorphism would be almost negligible.

The adamellite of the Strathbogies can be traced continuously from the neighbourhood of Seymour to the Broken River, near Nillahcootie. I have shown (22) that during the ascent of Mount Samaria, in this neighbourhood, granite, granite porphyry and quartz porphyry are successively met with, and there is little doubt that the three types belong to the one intrusion, the structural variation being due to the different pressures under which the rocks crystallised. The above rocks would be better described as adamellite, adamellite porphyry and quartz porphyrite. Eastward from Mount Samaria the prevailing type is a quartz porphyrite similar to that found at the summit of the mount.

The granular groundmass so typical in the dacites and the Strathbogie quartz porphyrite is generally absent in the Mount Samaria and Tolmie porphyrites, its place being taken by a fine-grained cryptocrystalline aggregate.

Hypersthene is absent in most sections examined, but several sections of the rock from Burn's Track, near Tatong, showed this mineral, and in these sections the granulitic groundmass was present. The field evidence shows that the quartz porphyrites of the Tolmie Highlands and of the Strathbogies belong to the one great period of intrusion, and this is supported by the general similarity of the micro-structure of the rocks in the two areas. This relationship has been given in some detail because the age of the dacites and allied rocks largely hinges on the evidence obtainable in this area.

The field evidence in the Macedon District shows that the dacites are post Upper Ordovician, and are younger than the Kainozoic igneous rocks of the area. The dacites of the Dandenong Ranges and Healesville are post-Silurian. The Strathbogie and Tolmie adamellites and quartz porphyrites are intruded into the Silurian, and these rocks in the southern portion of the Tolmie area are

overlain by the Mansfield sandstones. There is some little doubt as to the age of these sandstones, as McCoy (11) described them as equivalent to the Old Red sandstone, but later Woodward (24) has placed them in the Lower Carboniferous. In any case, however, the age of these rocks in the north-east of Victoria is confined to fairly narrow limits. They are post-Silurian and pre-Lower Carboniferous, i.e., they are almost certainly Devonian. Enormous earth movements marked the opening of the Devonian in Victoria, and there is no evidence of intense earth movement in Middle and Upper Devonian, so that the inference is that the intrusion of these igneous rocks accompanied these Lower Devonian earth movements, and consequently are of Lower Devonian age.

The closely-marked similarity between the mineralogical and micro-structural features of the dacites and the quartz porphyrites lead one to the conclusion that they belong to the one great period of igneous activity, so that the dacites and grano-diorites of Macedon, Dandenong and Healesville, in the absence of other evidence, may be classed as Lower Devonian.

Dr. Howitt (7) has shown that the Snowy River porphyries are Lower Devonian in age, so that there is a strong probability that the dacites and Snowy River Porphyries are genetically related. Unfortunately the Snowy River Porphyries cannot be included in this discussion, as no analyses of these rocks have been made.

In Central Victoria are numerous occurrences of granite rocks, and there range from granodiorite through adamellite to normal granite.

Mr. Stillwell (20) has described the granitic rock of Broadmeadows as adamellite, and gives an analysis by Mr. H. C. Richards of a specimen from Gellibrand Hill. Professor Skeats (16) has described the rock from Mount Eliza, in the Mornington Peninsula, as a grano-diorite, and gives an analysis of the rock estimated by means of Rosival's method. The large mass of granitic rocks extending in a rude semi-circle to the north of Castlemaine and Maldon contains various types, but that from the Harcourt quarries is on the border line between the adamellites and granodiorites. An analysis of this rock was made some few years ago by Mr. G. Ampt, and is given later.

North-west of Bacchus Marsh, near Ingliston, is an intrusion of adamellite (provisional name). This has been analysed by Mr. A. G. Hall at the Mines Department Laboratory, and the analysis will be given later.

Sections of the granitic rocks near Bulla show that these rocks are at the alkalic end of the granodiorites.

Professor Skeats (17) has described the rock from Station Peak, in the You Yangs, as a granite containing anorthoclase.

Exceedingly similar in the hand specimen and under the microscope to the Station Peak granite, but somewhat finer in grain, is the granite from the Dog Rocks near Geelong.

Microscopical examination shows that the rocks from Cape Woolamai, Gabo Island, and Mt. Buffalo are granites, and are easily distinguishable from the granodiorites of Central Victoria. This difference in the microscopial characters led to the belief that there were two types of granitic rocks in Victoria, which were quite distinct in their chemical characters, and had no genetic relationship with one another. At first sight chemical analyses, to be quoted later, seem to uphold this view. The granodiorites are intruded into both the Ordovician and Silurian sedimentary series, whereas at present no true granitic rocks are known within the Silurian area. This led to the view that whereas the granodiorites were post-Silurian, the granites might possibly be pre-Silurian.

There is no exposed contact between the granites of the You-Yangs or the Dog Rocks with fossiliferous sediments, but there is little doubt that these granites are related to those of Maude, which are intruded into sandstones and slates belonging to the Darriwell horizon of the Lower Ordovician. The Mt. Buffalo granite is intruded into the Upper Ordovician.

Evidence, however, will be adduced from a study of chemical analyses of some of these rocks to show that the granites and granodiorites are gentically related to one another.

(c) *Lilydale Devonian Series.*

Recently Mr. M. Morris has been working on a series of igneous rocks which occur in the neighbourhood of Lilydale. Analyses of four of the types have been made at the Mines Department Laboratory, and these are of considerable interest owing to their variation from the normal dacites of the Dandenong Ranges, with which they are intimately connected. Mr. Morris has kindly allowed me to use these analyses, but no description of the microscopical characters or field relations can be given here.

(d) *Macedon Kainozoic Series.*

During the Kainozoic Period Victoria was the centre of intense vulcanicity. Extensive flows of basalt covered a considerable area of Southern Victoria, while isolated patches are fairly widely distributed throughout the State.

The early geological survey of Victoria subdivided these basalt rocks into older and newer Volcanic. In some cases where the lavas come into relation with the Kainozoic marine series the age can be fairly definitely fixed, but in a large number of cases field evidence as to exact age is wanting. Professor Skeats (15) has discussed the relative ages of these basalts and has pointed out that "the reference of a basalt to the older or newer series is frequently based only on conjecture or analogy."

The basalts of the plains to the north of Melbourne, however, clearly belong to the younger series, as they overlie the Kainozoic marine series at Essendon, Keilor and elsewhere.

The plains are continuous up to the slopes of Mount Macedon, and there is not the slightest doubt that the basalts of the plains near Macedon belong to the newer series.

Somewhat older than these basalts are the interesting series of alkaline rocks which flank the slopes of Mount Macedon.

The alkali rocks which have been recognised in the Macedon District consist of solvsbergite, anorthoclase trachyte, anorthoclase olivine trachyte, olivine anorthoclase trachyte, limburgite, macedonite, woodendite, and anorthoclase basalt. For reason given in the paper on the Macedon District, Professor Skeats and the author consider the probable order of extrusion was:—

1. Anorthoclase trachyte.
2. Solvsbergite.
3. Anorthoclase basalt, Macedonite, Woodendite.
4. Anorthoclase olivine trachyte, Olivine anorthoclase trachyte.
5. Limburgite.

The solvsbergites are in the form of plugs at the Camel's Hump, Hanging Rock and Brock's Monument, while the remaining types occur as more or less widely spread lava flows. The age of these rocks is considered to be probably mid-Kainozoic.

III. Differentiation of the Rocks.

One of the most interesting problems to the petrologist is that of the causes which give rise to the great diversity of types of igneous rocks. As has been stated earlier, the aim in the present paper is rather to show the relationships of the end products than to attempt an explanation of the causes which have led to the production of the various types belonging to any one series.

Harker (4) has shown that the serial relationship of the rocks of any petrographic province may be expressed by means of variation diagrams constructed with the silica percentages of the several

rocks taken as abscissae, and the percentages of the other constituents as ordinates. Such a variation diagram was constructed, based on the analyses of the Macedon granodiorite-dacite series, and is given in Fig. 1.

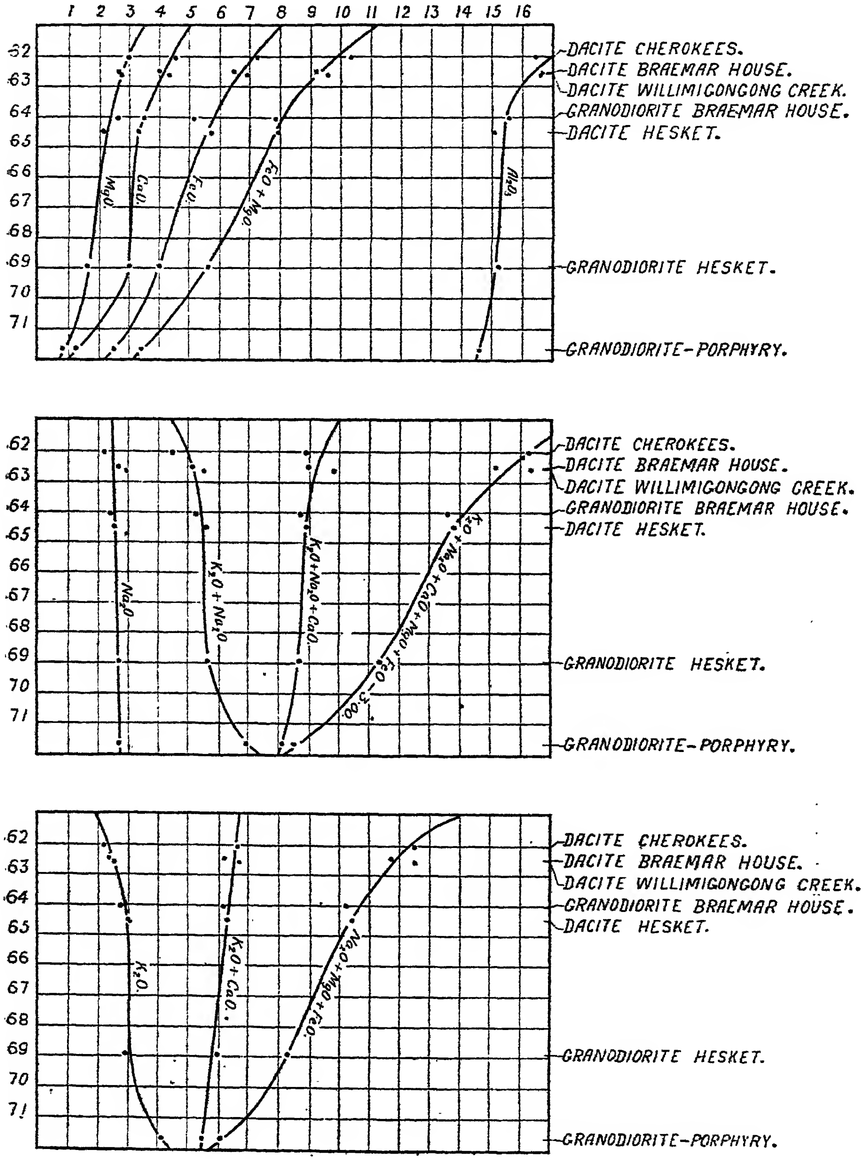


Fig. 1.

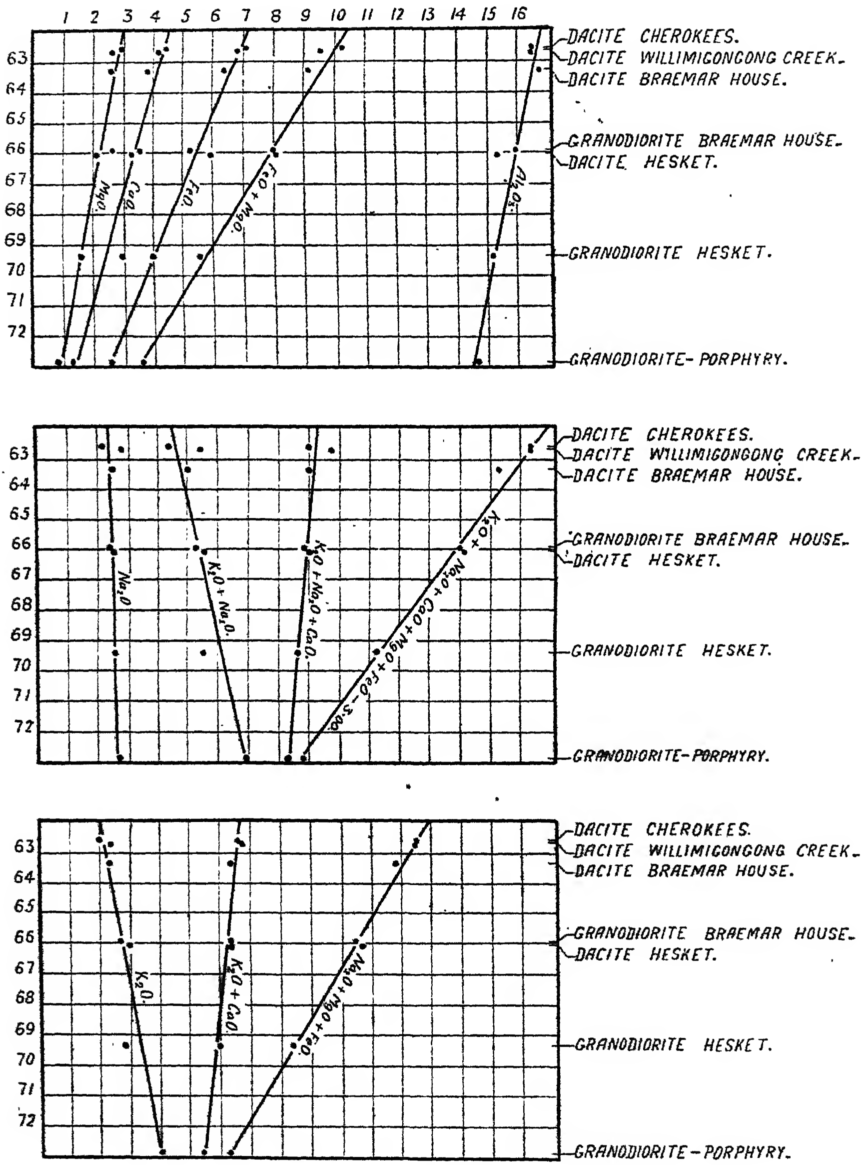

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
63
64
65
66
67
68
69
70
71
72
MgO.
CaO.
FeO.
FeO + MgO.
Al_2O_3.
DACITE CHEROKEES.
DACITE WILLIMIGONGONG CREEK.
DACITE BRAEMAR HOUSE.
GRANODIORITE BRAEMAR HOUSE.
DACITE HESKET.
GRANODIORITE HESKET.
GRANODIORITE-PORPHYRY.
Na_2O
$K_2O + Na_2O$.
$K_2O + Na_2O + CaO$.
$K_2O + Na_2O + CaO + MgO + FeO - 5.00$.
K_2O.
$K_2O + CaO$.
$Na_2O + MgO + FeO$.

Fig. 2.

As the analyses showed a considerable range in the amount of water, and as the totals varied somewhat, it was felt that the analyses as they stood were not quite comparable with one another, so that the analyses were recalculated to 100 per cent. with the water omitted. Portion of the ferrous oxide originally present in the rocks had been converted to ferric oxide, and as the amount of oxidation varied it was thought better to calculate all the iron as ferrous oxide, and manganous oxide was added to the ferrous oxide.

A second variation diagram based on these recalculated analyses was made, and is given in Fig. 2. The difference between these two diagrams is very marked, as Fig. 1 shows a series of sigmoidal curves, whereas in Fig. 2 the variation is expressed by straight lines. As this second diagram was considered to bring out the relationship of the various types to one another better than was the case in the first diagram, other diagrams used in the paper have been plotted from recalculated analyses.

(a) *The Macedon Granodiorite-Dacite Series.*

Seven analyses of rocks belonging to this series have been made in the Mines Department Laboratory, and these are given in Table I.

TABLE I.

	I.	II.	III.	IV.	V.	VI.	VII.
SiO -	62.04	62.54	62.56	64.04	64.48	68.92	71.65
Al_2O_3 -	16.50	16.66	16.60	15.58	15.07	15.26	14.56
Fe_2O_3 -	0.66	1.04	1.02	0.80	0.60	0.80	1.13
FeO -	6.67	5.54	5.98	4.47	5.19	3.30	1.56
MgO -	3.06	2.68	2.70	2.64	2.17	1.64	0.84
CaO -	4.56	3,92	4.30	3.52	3.31	3.04	1.27
Na_2O -	2.27	2.66	2.98	2.42	2.55	2.71	2.76
K_2O -	2.14	2.47	2.57	2.80	3.04	2.93	4.14
$H_2O +$ -	0.54	0.46	0.68	2.25	2.01	1.04	0.15
$H_2O -$ -	0.16	0.17	0.18	0.38	0.13	0.22	1.20
CO_2 -	nil.	nil.	nil.	nil.	tr.	nil.	nil.
TiO_2 -	1.16	1.20	1.10	0.80	0.90	0.70	0.35
P_2O_5 -	0.19	0.20	0.17	0.18	0.22	0.19	0.12
Mno -	tr.	tr.	tr.	tr.	0.11	tr.	0.04
Li_2O -	nil.	tr.	tr.	tr.	tr.	tr.	st. tr.
Cl -	tr.	tr.	tr.	tr.	tr.	nil.	tr.
NiO -	—	—	—	—	0.01	—	nil.
CoO -	—	—	—	—	0.01	—	nil.
FeS_2 -	nil.	nil.	nil.	nil.	—	nil.	—
SO_3 -	—	—	—	—	nil.	—	—
Total -	99.95	99.54	100.85	99.88	99.79	100.75	99.77
Sp. Gr. -	7.789	2.781	2.773	2.722	2.708	2.688	2.630

I. Dacite, ¾ miles south-west of Cherokees.
II. Dacite, 50 yards south of Braemar House Stable.
III. Dacite, Willimigongong Creek, Upper Macedon.
IV. Granodiorite, near Braemar House.
V. Dacite, 1 mile west of Hesket.
VI. Granodiorite, near old Sawmill, Hesket.
VII. Granodiorite, Porphyry, Barringo Creek.

For reasons given above these analyses were recalculated to 100 per cent. with the water omitted, and all the iron reckoned as ferrous oxide. These recalculated analyses are given in Table II., arranged in order of increasing silica percentage :—

TABLE II.

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2 -	62.59	62.64	63.29	65.90	66.04	69.33	72.88
Al_2O_3 -	16.65	16.62	16.86	16.03	15.46	15.35	14.81
FeO -	7.26	6.91	6.56	5.35	6.03	4.04	2.67
MgO -	3.09	2.70	2.71	2.72	2.22	1.65	0.85
CaO -	4.60	4.30	3.97	3.62	3.39	3.06	1.30
Na_2O -	2.29	2.99	2.69	2.49	2.61	2.73	2.81
K_2O -	2.16	2.57	2.50	2.88	3.11	2.95	4.20
TiO_2 -	1.17	1.10	1.22	0.82	0.92	0.70	0.36
P_2O_5 -	0.19	0.17	0.20	0.19	0.22	0.19	0.12
Total -	100.00	100.00	100.00	100.00	100.00	100.00	100.00

I. Dacite, ¾ mile south-west of Cherokees.
II. Dacite, Willimigongong Creek, Upper Macedon.
III. Dacite, 50 yards south of Braemar House Stable.
IV. Granodiorite, near Braemar House.
V. Dacite, 1 mile west of Hesket.
VI. Granodiorite, near old Sawmill, Hesket.
VII. Granodiorite porphyry, Barringo Creek.

It will be seen that the only difference in the order of the analyses in the two tables is that the Braemar House and the Willimigongong Creek dacites change places.

As already pointed out, there is a very marked difference in the shape of the graphs in the two variation diagrams plotted from the original and the recalculated analyses respectively. In the second diagram the relationship of the different types to one another agrees with Harker's "linear variation" as the percentage of each oxide is a linear function of the silica percentage.

One interesting point was noted in regard to the recalculated analyses of these dacite and granodiorite, viz., that the sum of the molecular ratios was approximately a constant figure. The molecular ratios of these rocks are given in Table III. :—

TABLE III.

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2 -	1.043	1.044	1.055	1.098	1.101	1.156	1.215
Al_2O_3 -	.164	.163	.166	.157	.152	.151	.145
FeO -	.101	.096	.092	.075	.084	.056	.037
MgO -	.077	.068	.068	.068	.056	.041	.021
CaO -	.082	.077	.071	.064	.061	.055	.023
Na_2O -	.037	.048	.044	.040	.042	.044	.045
K_2O -	.023	.028	.027	.031	.033	.032	.045
TiO_2 -	.015	.014	.015	.010	.011	.009	.005
P_2O_5 -	.001	.001	.001	.001	.001	.001	.001
Total -	1.543	1.539	1.539	1.544	1.541	1.545	1.537

I. Dacite, Cherokees.
II. Dacite, Willimigiongong Creek.
III. Dacite, Braemar House.
IV. Granodiorite, Braemar House.
V. Dacite, Hesket.
VI. Granodiorite, Hesket.
VII. Granodiorite Porphyry, Barringo Creek.

It must be admitted that these recalculated analyses do not truly represent the composition of the different types, as there is no allowance made for the presence of ferric iron or magmatic water; but still the above result must be considered significant.

If we use the term "unit molecular concentration" to indicate the sum of the molecular ratios, then in the case of the Macedon granodiorite-dacite series the unit molecular concentration remained constant throughout the various stages in the differentiation of these rocks. It will be seen later that there is apparently a relationship between the molecular concentration and the shape of the variation curves.

(b) *Victorian Upper Palaeozoic Series.*

Besides the rocks of the Macedon area, analyses have been made of other dacites, granodiorites, etc., belonging to the Upper Palaeozoic of Victoria.

Several analyses of rocks from the Dandenong and Healesville district were made some years back at the Mines Department Laboratory, but the methods used were such that too much reliance cannot be placed on the results.

In 1908 Mr. H. C. Richards (12) analysed the dacite from near Upwey, in the Dandenong Ranges, and this analysis compares very closely with those of the Macedon dacites.

Thanks to the courtesy of Mr. E. J. Dunn, late Director of the Geological Survey of Victoria, several analyses of granitic rocks

have been made for me at the Mines Department Laboratory. Excluding the Macedon and Lilydale rocks, all the superior analyses of the Victorian Lower Palaeozoic igneous rocks are given in Table IV.

TABLE IV.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
SiO_2 -	63.27	67.75	69.19	70.51	70.94	71.57	72.49	73.30	75.99	76.31
Al_2O_3	16.50	16.11	13.45	14.36	13.99	13.58	13.48	13.84	13.10	13.09
Fe_2O_3	0.68	0.50	2.71	0.33	0.35	1.18	1.16	0.82	0.57	0.41
FeO -	5.10	4.00	2.78	1.95	3.02	2.19	2.09	1.22	0.61	1.07
MgO	2.48	0.79	1.06	1.08	0.80	1.07	0.49	0.82	0.18	0.36
CaO -	4.18	2.68	2.04	2.98	2.35	1.72	1.31	0.84	0.41	0.65
Na_2O	2.36	2.60	2.89	3.17	3.94	2.79	3.38	3.12	3.30	3.00
K_2O +	2.68	3.42	3.94	3.15	3.66	4.36	4.06	4.89	5.27	4.76
H_2O –	0.52	0.96	0.77	1.18	0.21	0.69	0.76	0.50	0.40	0.29
H_2O -	0.09	0.20	0.16	—	0.11	0.11	0.18	0.19	0.14	0.11
CO_2 -	nil.	nil.	0.07	nil.	nil.	0.29	trace	nil.	nil.	0.66
TiO_2 -	1.30	0.85	0.51	1.20	0.58	0.46	0.46	0.20	0.11	0.20
P_2O_5 -	0.15	0.09	0.18	0.12	trace	0.11	trace	0.08	trace	trace
MnO -	0.03	trace	0.14	trace	nil.	0.09	0.13	0.15	0.06	0.11
Li_2O -	trace	—	trace	—	—	st.tr.	trace	nil.	trace	trace
Cl -	—	—	trace	—	—	trace	trace	nil.	trace	trace
NiO -	—	—	nil.	0.08	—	nil.	nil.	nil.	0.02	0.01
CoO -	—	—	nil.	—	—	nil.	nil.	nil.	trace	—
Cr_2O_3	—	—	—	trace	—	—	—	—	—	—
SO_3 -	—	—	nil.	—	—	nil.	nil.	nil.	nil.	nil.
FeS_2 -	0.16	—	—	—	—	—	—	—	—	—
BaO -	—	—	—	—	—	—	—	—	nil.	—
Total -	99.50	99.95	99.89	100.11	99.95	100.21	99.99	99.97	100.16	100.43
Sp. Gr.	2.76	2.68	2.666	—	—	2.655	2.635	—	2.620	2.643

I. Dacite, Upwey.[1] (Analyst, H. C. Richards.)
II. Adamellite[2], Granite Quarry, Mt. Gellibrand, Broadmeadows. (Analyst, H. C. Richards.)
III. Adamellite, Trawool Quarry. (Analyst, A. G. Hall.)
IV. Hypersthene quartz porphyrite, Road Metal Quarries, Violet Town. (Analyst, G. Ampt.)
V. Granodiorite, Harcourt Quarry. (Analyst, G. Ampt.)
VI. Adamellite, Ingliston. (Analyst, A. G. Hall.)
VII. Granite, Gabo Island. (Analyst, J. Watson.)
VIII. Granite,[3] Mount Buffalo. (Analyst, A. G. Hall.)
IX. Granite, Dog Rocks, Geelong. (Analyst, A. G. Hall.)
X. Granite, Cape Woolamai. (Analyst, A. G. Hall.)

These analyses have been recalculated to 100 per cent. with the total iron converted to ferrous oxide and the water omitted. Man-

1. Proc. Roy. Soc. Victoria, vol. xxi. (N.S.), Pt. II., 1909, p. 533,
2. Proc. Roy. Soc, Victoria, vol. xxiv. (N.S.), Pt. I., 1911, p. 177.
3. Memoirs of Geol. Surv. of Victoria, No. 6, 1908, p. 8.

ganous oxide is added to the ferrous oxide. These recalculated analyses, together with those of the Macedon Rocks, are given in Table V., arranged in order of increasing silica percentage.

TABLE V.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
SiO_2 -	62.59	62.64	63.29	64.06	65.90	66.04	68.61	69.33	70.17
Al_2O_3 -	16.65	16.62	16.86	16.71	16.03	15.46	16.31	15.35	13.63
FeO -	7.26	6.91	6.56	5.91	5.35	6.03	4.51	4.04	5.43
MgO -	3.09	2.70	2.71	2.52	2.72	2.22	0.80	1.65	1.07
CaO -	4.60	4.30	3.97	4.23	3.62	3.39	2.72	3.06	2.07
Na_2O -	2.29	2.99	2.69	2.39	2.49	2.61	2.64	2.73	2.93
K_2O -	2.16	2.57	2.50	2.72	2.88	3.11	3.46	2.95	4.00
TiO_2 -	1.17	1.10	1.22	1.31	0.82	0.92	0.86	0.70	0.52
P_2O_5 -	0.19	0.17	0.20	0.15	0.19	0.22	0.09	0.19	0.18
Total -	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
SiO_2 -	70.73	71.24	71.29	72.29	72.88	73.30	73.89	76.34	76.37
Al_2O_3 -	14.08	14.04	14.52	13.72	14.81	13.62	13.95	13.16	13.10
FeO -	3.90	3.34	2.37	3.37	2.67	3.29	2.13	1.20	1.56
MgO -	1.08	0.80	1.09	1.08	0.85	0.50	0.83	0.18	0.36
CaO -	2.54	2.36	3.01	1.74	1.30	1.32	0.85	0.41	0.65
Na_2O -	3.05	3.96	3.18	2.82	2.81	3.41	3.14	3.31	3.00
K_2O -	3.61	3.68	3.21	4.41	4.20	4.10	4.93	5.29	4.76
TiO_2 -	0.86	.58	1.21	0.46	0.36	0.46	0.20	0.11	0.20
P_2O_5 -	0.15	tr.	0.12	0.11	0.12	tr.	0.08	tr.	tr.
Total -	100.00	100.00	100.00	100.00	100.00	100.000	100.00	100.000	100.00

I. Dacite, Cherokees, Macedon District.
II. Dacite, Willimigongong Creek, Macedon District.
III. Dacite, Braemar House, Macedon District.
IV. Dacite, Upwey, Mount Dandenong District.
V. Granodiorite, Braemar House, Macedon District.
VI. Dacite, Hesket, Macedon District.
VII. Adamellite, Broadmeadows.
VIII. Granodiorite, Hesket, Macedon District.
IX. Adamellite, Trawool, Strathbogie District.
X. Average of Adamellite and Quartz Porphyrite, Strathbogie.
XI. Granodiorite, Harcourt.
XII. Quartz-porphyrite, Violet Town, Strathbogie District.
XIII. Adamellite, Ingliston.
XIV. Granodiorite porphyry, Barringo Creek, Macedon District
XV. Granite, Gabo Island.
XVI. Granite, Mount Buffalo.
XVII. Granite, Dog Rocks, Geelong.
XVIII. Granite, Cape Woolamai.

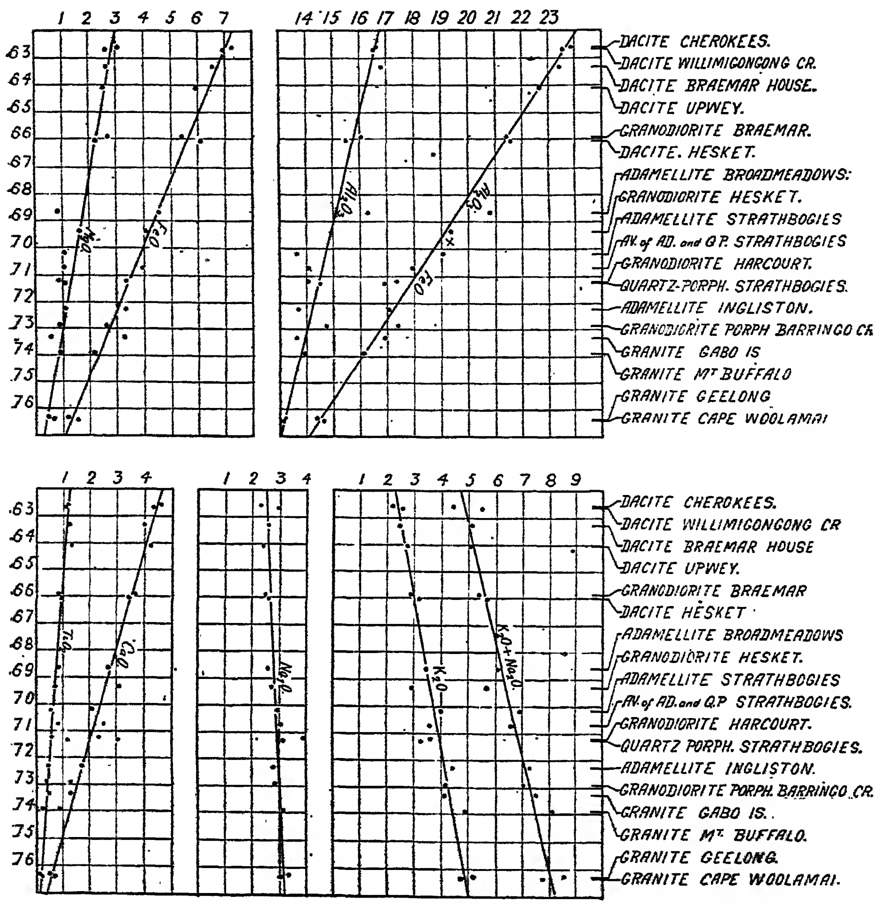


Fig. 3.

A variation diagram has been plotted from these recalculated analyses, and is given in Fig. 3. It will be seen that the variation is of linear type, and that on the whole the various points conform very closely to the graphs. The adamellite from Broadmeadows shows a positive departure in the alumina, and an equal negative departure in the magnesia, while the remaining oxides conform remarkably well. The two rocks from the Strathbogies show decided departures in some cases, but the mean of these two analyses gives points which fall close to the lines. The Harcourt granodiorite shows little departure except in the soda. The four granites conform remarkably well to the graphs.

If variation curves have any real significance, and there seems no doubt that they have, then we must infer that all the rocks whose analyses have been used in the construction of this diagram are genetically related. In this diagram only first-class analyses have been used, and so those of the dacites of Dandenong Ranges and the Black's Spur have been rejected for reason already given.

Analyses by Dr. Howett of quartz-mica-diorites were not included, as titanium oxide had not been estimated and the methods of analysis as used by him were not as exact as those in use at the present day.

The molecular ratios for the different oxides present in the re-calculated analyses and their totals were determined, and it was found that in this case also the total molecular ratios, or using the term suggested earlier, "the unit molecular concentration," remained approximately constant throughout the differentiation. These molecular ratios are given in Table VI.

TABLE VI.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
SiO_2 -	1.043	1.044	1.055	1.068	1.098	1:101	1.144	1.156	1.170
Al_2O_3 -	.164	.163	.166	.164	.157	.152	.160	.151	.133
FeO -	0.101	0.96	.092	.082	.075	.084	.063	.056	.075
MgO -	.077	.068	.068	.063	.068	.056	.020	.041	.027
CaO -	.082	.077	.071	.076	.064	.061	0.48	.055	.037
Na_2O -	.037	.048	.044	.039	.040	.042	.043	.044	.047
K_2O -	.023	.028	.027	.029	.031	.033	.037	.032	.043
TiO_2 -	.015	.014	.015	.015	.010	.011	.011	.009	.006
P_2O_5 -	.001	.001	.001	.001	.001	.001	.001	.001	.001
Total ..	1.543	1.539	1.539	1.538	1.544	1.541	1.527	1.545	1.539

	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
SiO_2 -	1.179	1.187	1.188	1.205	1.215	1.222	1.232	1.272	1.273
Al_2O_3 -	.138	.137	.142	.134	.145	.133	.137	.129	.128
FeO -	.054	.046	.033	.047	.037	.046	.029	.017	.022
MgO -	.027	.020	.027	.027	.021	.013	.021	.005	.009
CaO -	.045	.042	.054	.031	.023	.023	.015	.007	.012
Na_2O -	.049	.064	.052	.045	.045	.055	.051	.053	.048
K_2O -	.038	.039	.034	.047	.045	.044	.025	.056	.051
TiO_2 -	.011	.008	.015	.006	.005	.006	.003	.001	.003
P_2O5 -	.001	.000	.001	.001	.001	.000	.001	.000	.000
Total -	1.542	1.543	1.546	1.543	1.537	1.542	1.541	1.540	1.546

I. Dacite, Cherokees, Macedon District.
II. Dacite, Willimigongong Creek, Macedon District.
III. Dacite, Braemar House, Macedon District.
IV. Dacite, Upwey, Dandenong District.
V. Granodiorite, Braemar House, Macedon District.
VI. Dacite, Hesket, Macedon District.
VII. Adamellite, Broadmeadows.
VIII. Granodiorite, Hesket, Macedon District.
IX. Adamellite, Trawool, Strathbogie District.
X. Average of Adamellite and Quartz-porphyry, Strathbogie District.
XI. Granodiorite, Harcourt.
XII. Quartz porphyrite, Violet Town, Strathbogie District.
XIII. Adamellite, Ingliston.
XIV. Granodiorite porphyry, Barringo Creek, Macedon District.
XV. Granite, Gabo Island,
XVI. Granite, Mount Buffalo.
XVII. Granite, Dog Rocks, Geelong.
XVIII. Granite, Cape Woolamai.

If the variation diagram, Fig. 3, can be considered at all a picture of the nature of the differentiation of the magma which produced the various rock types shown, then it is certain that there must be limiting values beyond which differentiation cannot proceed. It is obvious that for any percentage of silica that percentage plus the percentages of the bases as read off on the diagram should in all cases equal one hundred. It follows then that when any line reaches the vanishing point, i.e., the percentage of the oxide represented by that line becomes nil, differentiation as indicated by the diagram must cease. The reason for this statement is that beyond that point the silica percentages plus the percentages of the bases, as indicated on the diagram, must be more than one hundred by the amount (a minus quantity) read off from the vanished line. In order to bring out this point clearly a fresh diagram has been drawn (see Fig. 4).

Two extreme values have been taken to plot the diagram, viz., the mean of the three dacites from Cherokees, Willimigongong Creek and Braemar House, and the mean of the granites from Dog Rocks and Cape Woolamai. The lines have been drawn exactly through these points so that the composition of any possible rock as read off from the diagram may equal one hundred per cent.

The two values used are as under. The molecular ratios are given in the second column in each case.

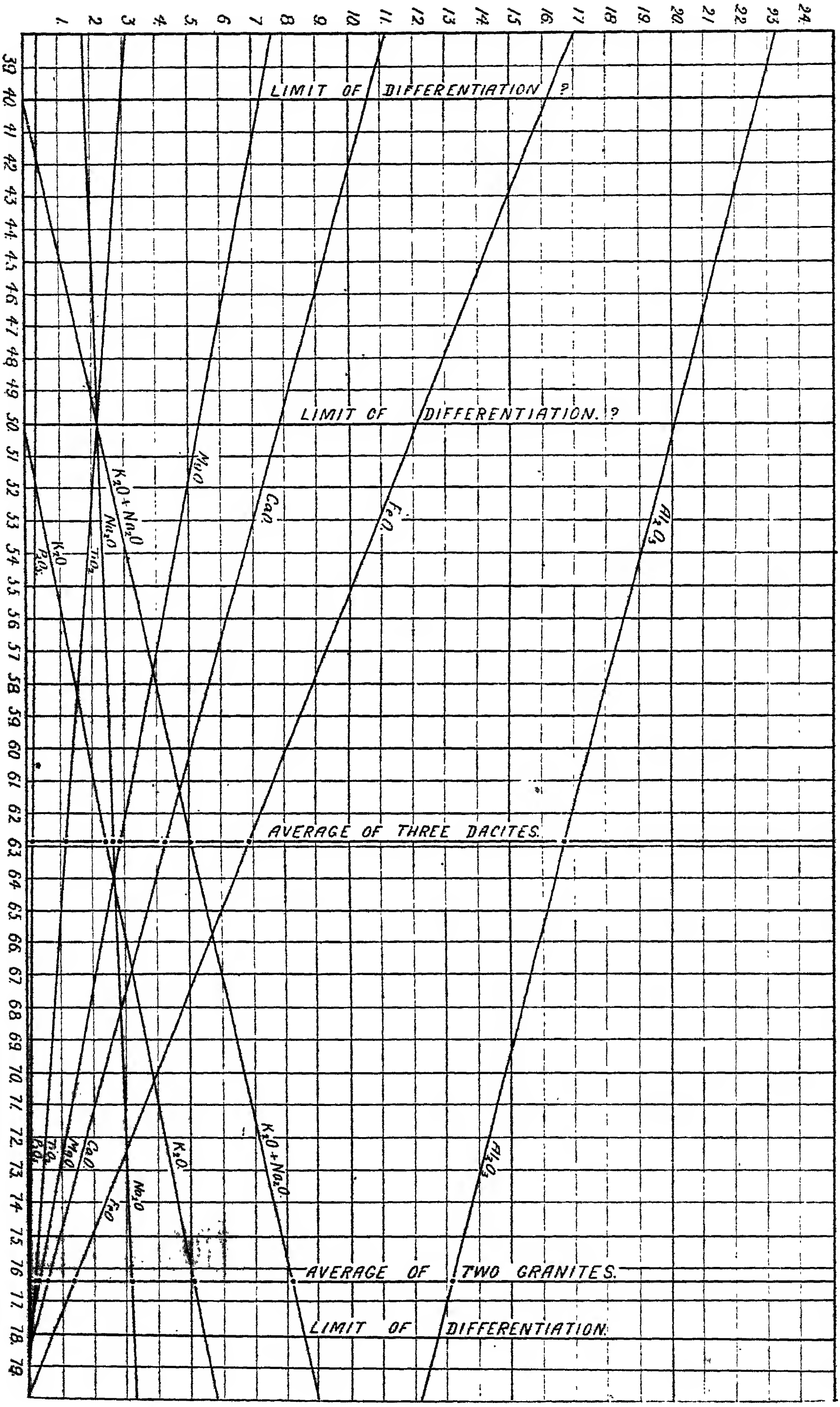

LIMIT OF DIFFERENTIATION ?
LIMIT OF DIFFERENTIATION. ?
AVERAGE OF THREE DACITES.
AVERAGE OF TWO GRANITES.
LIMIT OF DIFFERENTIATION.
MgO
CaO
FeO
Al_2O_3
K_2O+Na_2O
Na_2O
TiO_2
K_2O
P_2O_5

Fig. 4.

	I.		II.	
SiO_2 -	62.84	1047	76.36	1273
Al_2O_3 -	16.71	164	13.13	128
FeO -	6.91	96	1.38	19
MgO -	2.82	71	.27	7
CaO -	4.29	77	.53	10
Na_2O -	2.66	43	3.15	51
K_2O -	2.41	26	5.03	53
TiO_2 -	1.16	15	.15	2
P_2O_5 -	.19	1	tr.	—
Total -	100.00	1540	100.00	1543

I. Average of analyses of dacite from Cherokees, Willimigongong Creek and Braemar House.

II. Average of analyses of granite from Dog Rocks, Geelong, and Cape Woolamai.

The lines drawn through the points representing the percentage of the oxides are produced both ways. It will be seen that in the direction of increasing silica percentage the magnesia line vanished at 78 per cent. silica, and is closely followed by the lime. It is considered that a rock containing 78 per cent. silica is the most acid product that this magma could produce under this type of differentiation. A more acid rock than this could, however, be produced by a complementary subdivision of one of the possible products of the linear type of differentiation.

In the direction of decreasing silica percentage the potash line vanished at approximately 50 per cent. silica, and this point is a possible limit of differentiation in the basic direction. In working out other variation diagrams it has been found that whereas the total alkalies may show a linear type of variation the soda and potash lines may become curved. In this case, then, there is the possibility that differentiation may not reach a limit until the total alkalies become nil at about 40 per cent. silica. In reading off any composition below 50 per cent. the soda line must be disregarded and the soda read off from the total alkalies line. Compositions have been read off the diagram for every 5 per cent. increase of silica, and are given in Table VII., together with the most acid differentiation product containing 78 per cent. of silica.

TABLE VII.

	I.		II.		III.		IV.	
SiO_2 -	40.0	.667	45.0	.750	50.0	.833	55.0	.917
Al_2O_3 -	22.7	.223	21.4	.210	20.1	.197	18.8	.184
FeO -	16.2	.225	14.2	.197	12.1	.168	10.1	.140
MgO -	7.3	.183	6.3	.158	5.3	.133	4.4	.110
CaO -	10.6	.189	9.3	.166	7.8	.139	6.5	.116
Na_2O -	0.0	.000	1.0	.016	2.2	.033	2.4	0.39
K_2O -	0.0	.000	0.0	.000	0.0	.000	0.8	.009
TiO_2 -	2.9	.036	2.5	.031	2.2	.028	1.8	.023
P_2O_5 -	0.3	.022	0.3	.002	0.3	.002	0.2	.001
Total -	100.0	1.525	100.0	1.530	100.0	1.535	100.0	1.593

	V.		VI.		VII.		VIII.		IX.	
SiO_2 -	60.0	1.000	65.0	1.083	70.0	1.169	75.0	1.250	78.0	1.300
Al_2O_3 -	17.5	.172	16.1	.158	14.8	.145	13.2	.132	12.6	.124
FeO -	8.0	.111	6.0	.083	4.0	.056	1.9	.026	0.7	.010
MgO -	3.4	.085	2.5	.063	1.5	.038	0.5	.013	0.0	.000
CaO -	5.1	.091	3.7	.066	2.3	.041	0.9	.016	0.1	.002
Na_2O -	2.6	.042	2.7	.044	2.9	.047	3.1	.050	3.2	.052
K_2O -	1.8	.019	2.8	.030	3.8	.040	4.8	.051	5.4	.057
TiO_2 -	1.4	.018	1.0	.013	0.6	.008	0.3	.004	0.0	.000
P_2O_5 -	0.2	.001	0.2	.001	0.1	.001	0.0	.000	0.0	.000
Total -	100.0	1.539	100.0	1.541	100.0	1.543	100.0	1.542	100.0	1.545

Naturally the most interesting compositions are those of the limiting members of the series. Taking the acid limit first, we find that such a composition would give practically pure quartz and felspar, as may be seen from the following:—

TABLE VIII.

	Percentage.	Molecular Ratios.	Orthoclase.	Albite.	Anorthite.	Quartz.	Remainder.
SiO_2 -	78.0	1.300	342	312	4	642	—
Al_2O_3 -	12.6	.124	57	52	2	—	.013
FeO -	0.7	.010	—	—	—	—	.010
MgO -	0.0	.000	—	—	—	—	—
CaO -	0.1	.002	—	—	2	—	—
Na_2O -	3.2	.052	—	52	—	—	—
K_2O -	5.4	.057	57	—	—	—	—

Quartz -	.642 × 60	=	38.52
Orthoclase -	.057 × 556	=	31.69
Albite -	.052 × 524	=	27.25
Anorthite -	.002 × 278	=	.56
			98.02

The FeO may be assumed to be present as magnetite, as the percentage of FeO also includes the Fe_2O_3, and the small amount of alumina is negligible considering the data on which the estimation is made. It would seem then that the acid limit product of the differentiation would be a rock consisting of approximately 38.5 per cent. free quartz and 59.5 per cent. felspar. In the case of the more acid of the hypothetical limits of differentiation in the direction of decrease of silica the composition may be estimated as follows :—

TABLE IX.

	Percentage.	Molecular Ratios.	Ilmenite.	Apatite.	Albite.	Anorthite.	Remainder.
SiO_2 -	50.0	.833	—	—	198	266	369
Al_2O_3 -	20.1	.197	—	—	33	133	31
FeO -	12.1	.168	28	—	—	—	140
MgO -	5.3	.133	—	—	—	—	133
CaO -	7.8	.139	—	6	—	133	—
Na_2O -	2.2	.033	—	—	33	—	—
K_2O -	0.0	.000	—	—	—	—	—
TiO_2 -	2.2	.028	28	—	—	—	—
P_2O_5 -	0.3	.002	—	2	—	—	—

It will be seen that there is more than sufficient silica left after the production of felspar to form a metasilicate of magnesia, ferrous iron and alumina. This excess of silica would be actually greater, as portion of the iron would go to form magnetite. If we allowed an equal amount of ferrous oxide for magnetite, as was required for ilmenite, viz., 28 parts, this would reduce the amount of ferrous iron by 84 points, and a possible composition of the hypothetical rock would be as under :—

Quartz - - -	$.149 \times 60$	$= 8.94$
Plagioclase - -	$\left\{ \begin{array}{l} .033 \times 524 = 17.29 \\ .133 \times 278 = 36.97 \end{array} \right\}$	$= 54.26$
Ilmenite - - -	$.028 \times 152$	$= 4.26$
Magnetite - -	$.028 \times 232$	$= 6.50$
Apatife - - -	$.002 \times 336$	$= .67$
Aluminous Amphibole -	$\left\{ \begin{array}{l} .031 \times 162 = 5.02 \\ .133 \times 100 = 13.30 \\ .036 \times 132 = 7.39 \end{array} \right\}$	$= 25.71$
		100.34

It will be seen that the rock would consist essentially of plagioclase and an aluminous amphibole or pyroxene with some quartz and a moderate amount of iron minerals.

Turing now to the more basic hypothetical limit of possible differentiation, the composition of the rock may be estimated in a similar manner, an equal amount of ferrous iron being allowed for magnetite as is required for ilmenite.

TABLE X.

	Percentage.	Molecular Ratios.	Apatite.	Ilmenite.	Magnetite.	Anorthite.	Aluminous Amphibole.	Remainder.
$SiO_{\frac{1}{2}}$ -	40.0	.667	—	—	—	366	304	-3
Al_2O_3 -	22.7	.223	—	—	—	183	40	—
Fe_2O_3 -	—	—	—	—	36	—	—	—
FeO -	16.2	.225	—	36	36	—	81	—
MgO -	7.3	.183	—	—	—	—	183	—
CaO -	10.6	.189	6	—	—	183	—	—
Na_2O -	0.0	.000	—	—	—	—	—	—
K_2O -	0.0	.000	—	—	—	—	—	—
TiO_2 -	2.9	.036	—	36	—	—	—	—
P_2O_5 -	0.3	.002	2	—	—	—	—	—

Anorthite - - -	$.183 \times 278$	$=50.87$
Aluminous* Amphibole	$\left\{\begin{array}{l} .040 \times 162 = 6.48 \\ .081 \times 132 = 10.69 \\ .183 \times 100 = 18.30 \end{array}\right\}$	$=35.47$
Magnetite - -	$.036 \times 232$	$= 8.35$
Ilmenite - - -	$.036 \times 152$	$= 5.47$
Apatite - - -	$.002 \times 336$	$= .67$

This composition seems a rather more rational end point than the other, as the rock would consist essentially of two minerals, anorthite and aluminous amphibole or pyroxene.

It is interesting to note that the ratio of the quartz to felspar is 39.3; 60.7 in the case of the acid limiting value, and that the ratio of the pyroxene to felspar in the case of the basic limit is approximately the same, viz., 41.1; 58.9.

While suggesting that these two values as read off from the diagram represent the theoretical limits of this linear differentiation, it does not follow that rocks with such composition would necessarily separate out from the given magma. In actual occurrence the composition of the original undifferentiated parent magma must be a controlling factor in limiting differentiation.

(c) *Macedon Kainozoic Alkali Series.*

All the leading types of rocks belonging to this series have been analysed at the Mines Department Laboratory, and in all nineteen first-class analyses have been made. These are given in Table XI.

*This is not a true metasilicate as the Al_2O_3 and SiO_2 are combined in the proportion 1 : 1, but an examination of a number of analyses of aluminous amphiboles and pyroxenes shows that generally silica must be allotted to alumina in the above proportion.

TABLE XI.

	I.	II.	III.	IV.	V.	V.	VII.	VIII.	IX.	X.
SiO_2 -	43.06	43.24	43.58	43.82	45.10	47.02	48.83	50.14	51.48	51.52
Al_2O_3 -	13.06	13.19	11.46	12.90	12.86	12.52	16.69	16.91	16.34	16.58
Fe_2O_3 -	4.68	4.42	3.40	6.74	5.66	5.81	2.66	3.26	4.86	2.35
FeO -	8.10	8.46	9.13	6,25	7.10	5.83	8.40	9.15	5.14	7.68
MgO -	9.92	8.48	10.80	9.32	8.56	9.92	5.56	2.62	2.82	4.03
CaO -	9.30	9,32	9.88	9.44	9.10	8.38	7.95	5.18	4.70	6.10
Na_2O -	2.14	2.28	2.18	2.49	3.99	3.23	2.92	3.80	3.57	4.11
K_2O -	2.14	1.68	2.13	1.75	1.02	3.23	2.10	2.78	3.43	2.99
H_2O + -	2.53	2.46	2.40	1.70	1.53	0.70	0.66	2.16	1.62	0.22
H_2O – -	0.76	2.03	0.47	1.26	1.10	0.69	1.34	0.14	1.90	1.39
CO_2 -	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
TiO_2 -	3.60	3.15	3.32	3.50	3.50	2.60	2.85	1.90	2.62	2.15
P_2O_5 -	0.96	1.13	0.95	1.02	1.00	1.23	0.74	1.19	1.28	0.82
Mno -	0.43	0.18	trace	0.37	0.08	0.12	0.25	0.38	0.35	0.13
Li_2O -	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	nil.	st.tr.
Cl -	trace	trace	trace	trace	trace	trace	0.04	trace	trace	0.05
NiO, CoO -	—	—	—	—	—	—	—	—	nil.	0.06
SO_3 -	nil.	nil.	nil.	nil.	nil.	nil.	trace	nil.	nil.	nil.
Total -	100.68	100.02	99.70	100.56	100.60	100.28	100.99	99.61	100.11	100.18
Sp. Gr. -	2.935	2.901	2.995	2.995	2.854	2.888	2.870	2.786	2.760	2.787

	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.
SiO_2 -	51.72	54.06	59.44	59.52	60.10.	62.56	65.46	66.86	67.06
Al_2O_3 -	13.36	17.13	17.98	18.06	18.38	17.89	17.40	16.34	17.40
Fe_2O_3 -	2.80	6.10	2.28	3.76	2.22	4.98	3.00	2.38	2.24
FeO -	8.16	3.55	3.34	2.27	3.34	0.45	1.60	1.99	0.84
MgO -	7.20	3.05	0.78	0.78	1.30	0.18	0.09	0.22	0.26
CaO -	7.68	4.88	2.32	1.98	2.28	0.72	0.76	0.92	0.34
Na_2O -	2.87	3.97	5.36	5.38	5.30	5.06	6.51	6.01	5.88
K_2O -	1.34	3.29	4.77	5.03	4.57	5.13	4.74	4.07	4.10
H_2O + -	0.96	1.00	1.57	0.96	0.43	0.73	0.35	0.41	0.62
H_2O – -	1.61	0.80	0.70	0.88	0.96	1.30	0.52	0.18	0.71
CO_2 -	n.d	nil.	n.d.	n.d.	trace	n.d.	n.d.	n.d.	n.d.
TiO_2 -	2.30	1.95	0.79	0.67	0.69	0.38	0.24	0.21	0.16
P_2O_5	0.25	0.48	0.30	0.27	0.33	0.11	nil.	trace	trace
Mno -	trace	0.20	trace	trace	nil.	trace	trace	trace	trace
Li_2O -	nil.	trace	trace	trace	trace	trace	nil.	trace	trace
Cl -	trace	trace	trace	trace	nil.	nil.	trace	trace	trace
NiO, CoO -	—	0.3	—	—	—	—	—	—	—
SO_3 -	nil.	nil.	nil.	nil.	trace	trace	nil.	nil.	nil.
Total -	100.25	100.71	99.63	99.56	99.90	99.49	100.67	99.59	99.61
Sp. Gr. -	2.828	2.722	2.590	2.621	2.651	2.504	2.596	2.646	2.559

I. Limburgite, lower portion of King's Quarry.
II. Limburgite, No. 1 Quarry, Woodend.
III. Limburgite, No. 4 Quarry, Woodend.
IV. Limburgite, upper portion of King's Quarry.
V. Limburgite, No. 3 Quarry, Woodend.
VI. Woodendite, Old Racecourse Hill, Woodend.
VII. Anorthoclase Basalt, base of Sugarloaf Hill, N.N.E. of Woodend.
VIII. Macedonite, Emu Creek, Macedon District.
IX. Macedonite, Spring Mound, S.S.E. of Lancefield.
X. Olivine anorthoclase trachyte, Parish of Cobaw.
XI. Anorthoclase basalt, quarry at road corner N.N.E. of the Jim Jim.
XII. Anorthoclase olivine trachyte, summit of Sugarloaf Hill.
XIII. Anorthoclase trachyte, Quarry, Parish of Newham.
XIV. Anorthoclase trachyte, Turritable Fall, Upper Macedon.
XV. Anothoclase trachyte, eastern slope of Mount Eliza.
XVI. Anothoclase trachtye, McAlister's Rock, Parish of Newham.
XVII. Solvsbergite, Camel's Hump.
XVIII. Solvsbergite, Brock's Monument.
XIX. Solvsbergite, Hanging Rock.

As in the previous cases these analyses have been recalculated to 100 per cent., but where several analyses are extremely similar to one another the mean value is taken. Certain blends of analyses are also included.

TABLE XII.

		1.	2.	3.	4.	5.	6.	7.
SiO_2	-	45.31	47.78	49.48	51.66	51.69	51.84	52.44
Al_2O_3	-	13.15	12.73	16.92	17.43	16.13	16.21	16.87
FeO	-	12.95	10.45	11.19	12.84	11.07	10.91	10.15
MgO	-	9.74	10.08	5.63	2.71	5.06	4.97	4.10
CaO	-	9.74	8.51	8.05	5.35	6.55	6.47	6.21
Na_2O	-	2.71	3.28	2.96	3.93	3.29	3.40	4.18
K_2O	-	1.81	3.28	2.13	2.87	2.62	2.69	3.04
TiO_2	-	3.54	2.64	2.89	1.97	2.68	2.61	2.18
P_2O_5	-	1.05	1.25	0.75	1.24	0.91	0.90	0.83
Total	-	100.00	100.00	100.0	100.00	100.00	100.00	

		8.	9.	10.	11.	12.	13.
SiO_2		53.08	53.56	54.98	58.03	62.00	67.28
Al_2O_3	-	13.72	17.01	17.42	17.93	18.54	17.29
FeO	-	10.97	10.27	9.12	7.33	5.47	3.80
MgO	-	7.39	2.93	3.10	2.29	0.78	0.19
CaO	-	7.89	4.90	4.96	3.63	1.87	0.68
Na_2O	-	2.95	3.71	4.04	4.78	5.42	6.24
K_2O	-	1.38	3.57	3.35	4.16	5.01	4.36
TiO_2	-	2.36	2.72	1.98	1.35	0.65	0.20
P_2O_5	-	0.26	1.33	0.75	0.50	0.26	tr.
Total	-	100.00	100.00	100.00	100.00	100.00	100.00

1. Limburgite - Average of 5 analyses.
2. Woodenite - (Complementary).
3. Anorthoclase Basalt - (Complementary).
4. Macedonite - (Complementary)
5. Blend of Complementary Types.
6. Blend of Alkali types less acid Trachyte and Solvsbergite.
7. Olivine anorthoclase Trachyte (Cobaw Type)
8. Anothoclase Basalt - (Complementary).
9. Macedonite - (Complementary).
10. Anorthoclase Olivine Trachyte - (Sugarloaf Type).
11. Blend of Alkali Rocks.
12. Anorthoclase Trachyte - Average of 4 analyses.
13. Solvsbergite - Average of 3 analyses.

Variation diagrams based on these recalculated analyses are given in Fig. 5. The curves obtained are in general better than those plotted from the original analyses (compare with Plates VII.-IX., Bulletin No. 24, Geol. Surv. of Victoria 1912).

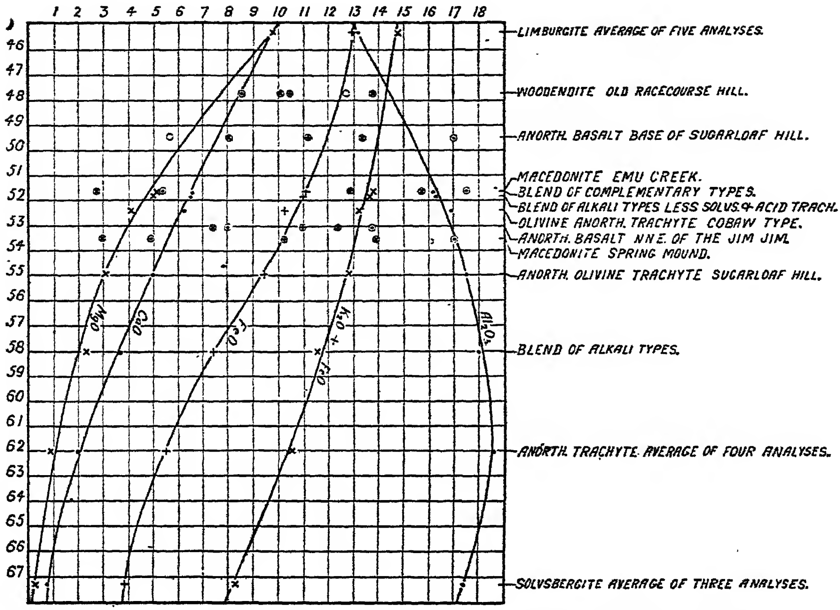
The differentiation of the Kainozoic alkali lavas of Macedon has been discussed in some detail (19), but some additions to this discussion may be included here.

In the first place, judging from the variation diagram (Fig. 4), differentiation must have proceeded on different lines to those exhibited by the dacite-granitic series. In the latter case variation could be expressed by straight lines, but the variation of the alkali rocks must be expressed by curves. It has been pointed out above that the molecular concentration of the Palaeozoic rocks remained constant throughout the differentiation.

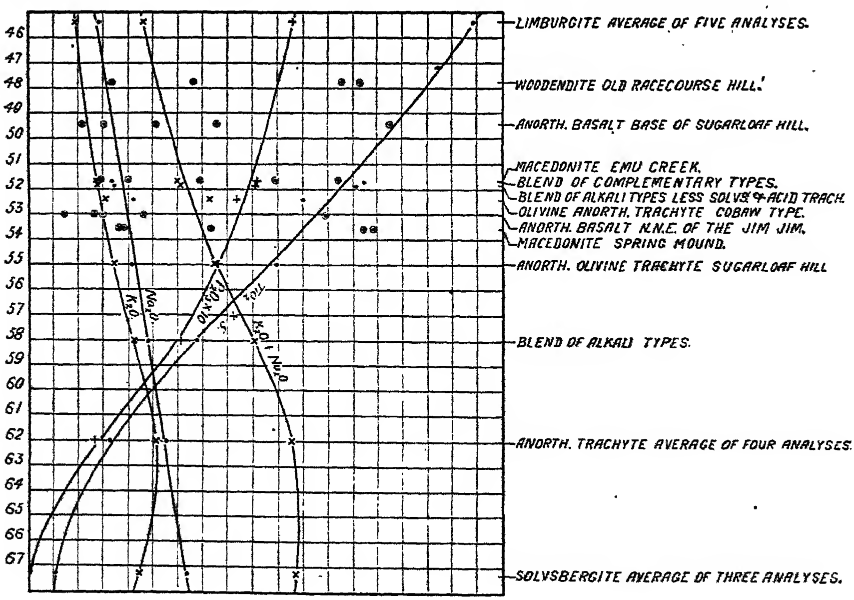
In the case of the rocks under consideration, however, this is not the case. The molecular ratios are set out in Table XIII., the order of the analyses being the same as in the preceding table.

TABLE XIII.

	1.	2.	3.	4.	5.	6.	7.
SiO_2 -	.755	.796	.825	.861	.862	.864	.874
Al_2O_3 -	.129	.125	.166	.171	.158	.159	.166
FeO -	.180	.145	.156	.178	.154	.151	.141
MgO -	.244	.252	.141	.068	.127	.124	.103
CaO -	.174	.152	.144	.096	.117	.115	.111
Na_2O -	.044	.053	.048	.064	.053	.055	.068
K_2O -	.019	.035	.022	.031	.028	.029	.032
TiO_2 -	.044	.033	.36	.025	.034	.033	.027
P_2O_5 -	.008	.099	.006	.008	.006	.006	.006
Total -	1.597	1.600	1.544	1.502	1.539	1.536	1.628



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67
MgO
CaO
FeO
$K_2O + Na_2O$
Al_2O_3
LIMBURGITE AVERAGE OF FIVE ANALYSES.
WOODENDITE OLD RACECOURSE HILL.
ANORTH. BASALT BASE OF SUGARLOAF HILL.
MACEDONITE EMU CREEK.
BLEND OF COMPLEMENTARY TYPES.
BLEND OF ALKALI TYPES LESS SOLVS. & ACID TRACH.
OLIVINE ANORTH. TRACHYTE COBAW TYPE.
ANORTH. BASALT N.N.E. OF THE JIM JIM.
MACEDONITE SPRING MOUND.
ANORTH. OLIVINE TRACHYTE SUGARLOAF HILL.
BLEND OF ALKALI TYPES.
ANORTH. TRACHYTE AVERAGE OF FOUR ANALYSES.
SOLVSBERGITE AVERAGE OF THREE ANALYSES.



46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67
K_2O
Na_2O
$P_2O_5 \times 10$
TiO_2
$K_2O + Na_2O$
LIMBURGITE AVERAGE OF FIVE ANALYSES.
WOODENDITE OLD RACECOURSE HILL.
ANORTH. BASALT BASE OF SUGARLOAF HILL.
MACEDONITE EMU CREEK.
BLEND OF COMPLEMENTARY TYPES.
BLEND OF ALKALI TYPES LESS SOLVS. & ACID TRACH.
OLIVINE ANORTH. TRACHYTE COBAW TYPE.
ANORTH. BASALT N.N.E. OF THE JIM JIM.
MACEDONITE SPRING MOUND.
ANORTH. OLIVINE TRACHYTE SUGARLOAF HILL
BLEND OF ALKALI TYPES.
ANORTH. TRACHYTE AVERAGE OF FOUR ANALYSES.
SOLVSBERGITE AVERAGE OF THREE ANALYSES.

Fig. 5.

TABLE XIII. (*Continued*).

	8.	9.	10.	11.	12.	13.
SiO_2 -	.885	.893	.916	.967	1.033	1.121
Al_2O_3 -	.134	.167	.171	.175	.181	.170
FeO -	.152	.143	.131	.102	.076	.053
MgO -	.185	.073	.078	.057	.020	.005
CaO -	.141	.088	.089	.065	.033	.012
Na_2O -	.048	.060	.065	.077	.087	.101
K_2O -	.015	.038	.036	.045	.053	0.47
TiO_2 -	.030	.034	.025	.017	.008	.003
P_2O_5 -	.002	.009	.006	.004	.002	—
Total -	1.592	1.505	1.517	1.509	1.493	1.512

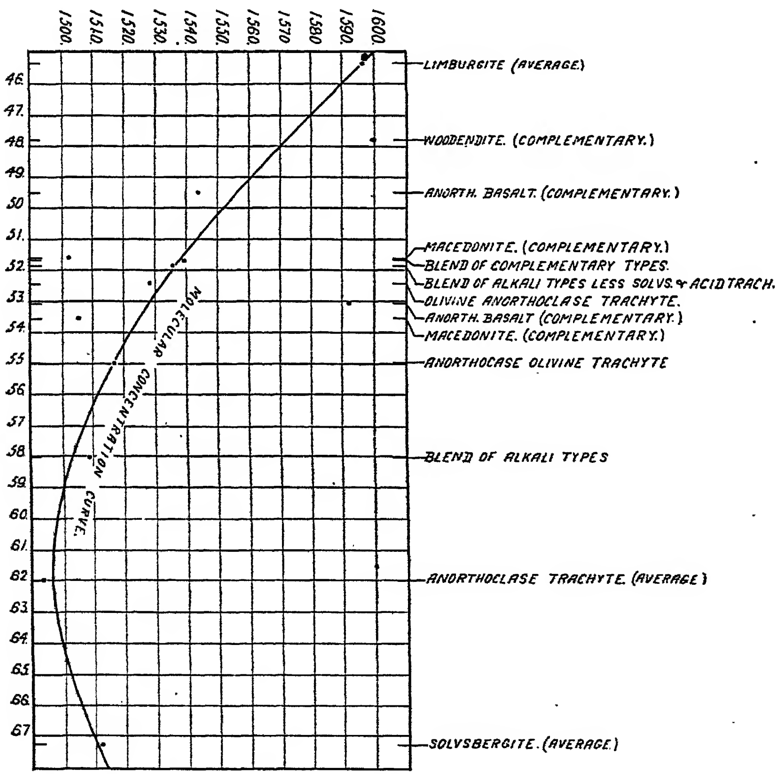


Fig. 6.

The molecular concentration of these analyses has been plotted and is given in Fig. 6. It will be noted that whereas the normal rocks of the series conform very closely to the curve, those rocks which have been described as complementary in origin depart

widely from the curve, but that the blend of the analyses of these rocks agrees closely with the curve.

In dealing with the differentiation of the Macedon alkali series the assumption was made that as the lavas had in general been poured over a fairly level plain, that their bulk would be approximately proportional to the areas occupied by them.

Working on the above assumption the average composition of the alkali rocks was determined, and is given as No. 11 in Tables XII. and XIII.

After the extrusion of the more acid types it was estimated that the composition of the residual magma would be approximately that given as No. 6 in Tables XII. and XIII.

It will be seen that this composition agrees very closely with that obtained by blending the so-called complementary types in proportion to area, and also with that of the anorthoclase olivine trachyte from Sugarloaf Hill. This suggests that after the extrusion of the solvsbergite and acid trachyte the residual magma split into two parts of similar composition, one of which gave rise to the anorthoclase olivine trachyte and limburgite, and the other portion split up to form the macedonite, woodendite and anorthoclase basalt.

It has been suggested that the differentiation of the alkali rocks may be subdivided into two forms—(1) Serial Differentiation, (2) Complementary Differentiation. To the Serial differentiation are assigned those types which conform to the curves, and which show a regular gradation in the percentage of the various constituent oxides. The remaining types show no such regularity in their variation, but appear to have been produced by an irregular subdivision of a partial magma, and consequently are considered to have been derived by complementary differentiation.

The serial differentiation of these alkali rocks may conveniently be referred to as curvilinear serial.

The probable limiting values of the curvilinear type of serial differentiation cannot be determined sufficiently accurately to be of any value, owing to the difficulty of satisfactorily producing the curves, but judging from the norms of the solvsbergites and limburgites the acid limit value would be composed of quartz and anorthoclase, and the basic limit value of anorthite and olivine with a concentration of magnetite, ilmenite and apatite.

The relationship of the Macedon alkali series to other Victorian alkali rocks and to the Newer Basalts has been discussed elsewhere (19). It was pointed out that the alkali lavas and the basaltic lavas in the Macedon area occur in such close juxtaposition and were

almost contemporaneous, so that the assumption that the alkali series and the basaltic series were derived from two separate and distinct magmas is hardly tenable. The conclusions may be cited :

"The authors believe that the Kainozoic volcanic rocks of Victoria were derived from a common magma. First came the separation and pouring out of the Older Basalts of the eastern and central portions of Victoria. This left a magma moderately rich in alkalies, and by some process of differentiation alkali magmas separated out into at least three lesser magma basins, viz., at Omeo, Macedon and Coleraine. On the exhaustion of these lesser magma basins, extrusion once more took place from the main reservoir, giving the Newer Basalt series."

It will be seen that the primary differentiation of the Macedon rocks is considered to have been the separation of the alkali magma from the basaltic magma, and that secondary differentiation of the serial and complementary types then ensued, and produced the various members of the alkali series.

(d) *Lilydale Devonian Series.*

As stated earlier, four analyses of rocks from the Lilydale area have been made at the Mines Department Laboratory, and these are given in Table XIV.

TABLE XIV.

	I.	II.	III.	IV.
SiO_2 -	65.83	68.19	68.73	69.93
Al_2O_3 -	14.89	14.98	13.16	15.14
Fe_2O_3 -	0.73	0.74	1.17	1.30
FeO -	4.63	2.74	2.74	2.33
MgO -	1.88	.029	1.22	0.26
CaO -	3.13	1.95	3.03	1.80
Na_2O -	2.12	3.34	2.30	3.36
K_2O -	2.34	3.64	2.59	3.55
H_2O+ -	2.41	1.40	1.86	0.83
H_2O- -	0.17	0.14	0.09	0.07
CO_2 -	0.47	1.93	1.50	nil.
TiO_2 -	0.89	0.20	0.50	0.20
P_2O_5 -	0.16	0.05	0.17	0.03
Cr_2O_3 -	trace	nil.	nil.	nil.
Mro -	0.10	0.08	0.09	0.05
NiO -	0.01	nil.	0.01	nil.
CoO -	nil.	nil.	nil.	nil.
BaO -	0.13	0.27	0.20	0.30
Li_2O -	nil.	nil.	tr.	tr.
S -	0.10	tr.	0.18	tr.
SO_3 -	nil.	nil.	nil.	nil.
Cl -	tr.	tr.	tr.	tr.
Total - -	99.97	99.94	99.54	99.15
Less = S -	.04	—	.07	—
Total -	99.93	99.94	99.47	99.15

I. Dacite, Dandenong Range.
II. Toscanite, Quarry 1 m. N.E. of Lilydale.
III. Dacite, Railway Cutting between Lilydale and Evelyn.
IV. Toscanite, about 1 m. E. of Mooroolbark.

The four analyses have been recalculated to 100 per cent., as in the case of previous analyses, and the results, together with the molecular ratios, are given in Table XV.

TABLE XV.

	I.		II.		III.		IV.	
SiO_2 -	68.01	1.134	70.76	1.179	71.30	1.188	71.76	1.196
Al_2O_3 -	15.39	.151	15.54	.152	15.43	.151	13.74	.134
FeO -	5.58	.078	3.62	.050	3.61	.050	4.06	.057
MgO -	1.95	.049	0.30	.007	0.26	.006	1.27	.032
CaO -	3.38	.061	2.29	.041	2.14	.038	3.37	.060
Na_2O -	2.19	.035	3.46	.056	3.42	.055	2.40	.039
K_2O -	2.40	.023	3.77	.040	3.61	.036	2.70	.026
TiO_2 -	0.93	.011	0.21	.003	0.20	.003	0.52	.006
P_2O_5 -	0.17	.001	0.05	.000	0.03	.000	0.18	.001
Total -	100.00	1.543	100.00	1.528	100.00	1.527	100.00	1.551

It is found that these analyses do not conform to the lines of variation of the dacite-granitic series, as shown in Fig. 3, or in the generalised diagram, Fig. 4. The unit molecular concentrations of three of the rocks show distinct departures from the mean concentration of the dacite-granitic series, viz., 1.541. In the case of the Macedon alkali rocks it has been seen that those rocks whose unit concentration departed from the normal variation for the series were probably derived by complementary differentiation. This suggests the possibility that these Lilydale rocks may have been produced by a similar form of differentiation. In this case there is an absence of quantitative data such as was available in the case of the Macedon rocks, and so no direct method is available for determining the relative proportions of the rocks. It is possible that an approximation to the truth may be obtained by combining the analyses in such proportions that the total molecular ratios of the resultant composition may be about equal to the mean molecular concentration of the granite dacites series, viz., 1.541. This result will be obtained by combining the analyses in the proportion of one part of each of the Analyses I., II. and III., and two parts of Analyses IV. One part each of Analyses I. and III., and two parts of Analyses II., and three parts of Analyses IV. will also give approximately the same molecular total.

TABLE XVI.

	I.		II.		III.	
SiO_2 -	70.72	1.175	70.87	1.181	70.8	1.180
Al_2O_3 -	14.77	.145	14.73	.144	14.5	.142
FeO -	4.18	.058	4.09	.057	3.6	.050
MgO -	1.01	.025	0.95	.024	1.4	.035
CaO -	2.91	.052	2.89	.052	2.1	.038
Na_2O -	2.77	.045	2.82	.045	2.9	.047
K_2O -	3.04	.032	3.09	.033	4.0	.043
TiO_2 -	.48	.006	0.44	.006	.6	.008
P_2O_5 -	.12	.001	0.12	.001	.1	.001
Total -	100.00	1.539	100.00	1.543	100.0	1.544

I. Blend of Lilydale Rocks in the proportion of one part each of I., II., and III., and two parts of IV.
II. Blend of Lilydale Rocks in the proportion of one part each of I. and III., and two parts of II., and three parts of IV.
III. Composition read off from diagram (Fig. 4).

It will be seen that these two blends agree fairly closely with the composition as read off from Fig. 4, and, furthermore, these two blends conform fairly well to the variation of the dacite-granitic series. Therefore there seems some justification in concluding that these Lilydale rocks may have been derived from the common stock magma of the dacite-granitic series, but that they have been evolved by complementary differentiation.

IV. Relationships of Igneous Rocks to Earth movements in Victoria.

In his Natural History of Igneous Rocks (4) Harker lays great stress on the apparent regional distribution of the so-called alkali and calcic rocks. He considers that the areas occupied by the alkali and sub-alkali groups correspond respectively with the areas of the Atlantic and Pacific types of coast line, as defined by Suess (21). Accordingly the names Atlantic and Pacific Branches of Igneous Rocks were suggested, but in a later publication (5) Harker seems to favour the terms Alkali and Calcic Branches.

It is proposed to discuss the relationship of some Victorian rocks to earth movements in order to see whether the Victorian evidence is in accord or not with Harker's generalisation. The rocks to be discussed are the Heathcotian diabases, the granites and dacites of the Upper Palaezoic and the Kainozoic basalts and alkali rocks.

(a) *Heathcotian Diabases.*

The diabases of Heathcote have been fully described by Dr. Howitt (8), Professor Gregory (3) and Professor Skeats (4), and the age of these rocks and similar types at Lancefield is now generally accepted as being between Middle Cambrian and basal Lower Ordovician. The Lower Ordovician rocks only occur at the surface to the west of the Heathcote-Lancefield line, except in the Mornington Peninsula, and Professor Gregory considered that the area in central Victoria now occupied by Silurian sediments was land surface during the deposition of the Ordovician Rocks, and that the Heathcote-Lancefield line represented the eastern limit of the Lower Ordovician.

Professor Skeats has shown that the cherts and diabases are interbedded, and that the former pass out conformably into normal sediments. The cherts have been shown to be due, at least in part, to the silification of stratified ash, and the inference is that this ash was either derived from submarine volcanoes or from a series of shore line volcanoes.

In the former case marine conditions must have extended eastward of this Heathcote-Lancefield line, and Lower Ordovician rocks should underlie the Silurian. If the latter supposition be correct, then this line may well represent the eastern limit of deposition. At present there is no positive evidence in favour of either of these views, but some negative evidence in favour of the latter, viz., the absence in this locality of known occurrences of Lower Ordovician sediments to the east of Heathcote, but the thick covering of Silurian rocks would completely mask any possible outcrop, so that this evidence is of very little value.

In either case, however, these eruptions of basic lava are more easily explained as accompanying fault action rather than fold action. The linear arrangement of the diabase in a north and south direction, giving rise to the Colbinabbin Range, suggests distribution along a fault line. Another possible explanation is that the linear arrangement is entirely due to the diabases and cherts occurring along the upper portion of an anticline.

Along the western limit of the outcrops in Victoria of Lower Ordovician sediments similar associations of diabases and cherts are found at Mount Stavely and at the Hummocks to the north of Casterton. The simplest explanation is that the Lower Ordovician marine transgression was caused by subsidence between two fault lines, i.e., the earth movements were of the Atlantic coast type. Movements of the Pacific coast type can give rise to a linear arrangement of the associated volcanoes, as evidenced in the great

chain of the Andes, but it is difficult to imagine such earth movements giving the requisite conditions for the production of interbedded submarine lavas and tuffs. While the evidence is not at all conclusive, I believe that the basic lavas of the Lower Ordovician were associated with fault movements and, according to Harker's generalisation, should show alkaline affinities.

(b) *Upper Palaeozoic Series.*

The intrusion of the granites and granodiorites and the associated volcanic rocks are undoubtedly associated with the intense earth movements to which the Ordovician and Silurian formations have been subjected. In the Macedon District (19) we have evidence of extensive earth movements subsequent to the deposition of the Lower Ordovician and prior to the deposition of the Upper Ordovician. The Kerrie Conglomerates have been shown to belong to the Upper Ordovician, and there is apparently a strong unconformity between these conglomerates and the underlying Lower Ordovician. The base of the Silurian is also marked by basal conglomerates, and the rocks of this system are in general less folded that those of the Upper Ordovician, so we may fairly safely infer considerable earth movements as marking the break between these two great periods of sedimentation. In the eastern part of Victoria Dr. Howitt (9) has shown that the Lower Devonian was a period of great igneous activity associated with intense earth folding. The Mansfield sandstones of Upper Devonian or Lower Carboniferous age rest unconformably on the upturned edges of the Silurian.

Folding over north and south axes was the prevailing type of tectonic movement to which the Ordovician and Silurian sediments were subjected, so that we can safely infer that the granites, granodiorites, dacites, etc., were associated with movements of the Pacific coast type.

(c) *Kainozoic Igneous Series.*

The Victorian basaltic rocks are certainly not associated with fold movements, because throughout the Kainozoic Period in Victoria there is no evidence of any earth movement of this type except of a purely local character. On the other hand there is abundant evidence of Kainozoic faulting. I understand that Mr. D. J. Mahony is working out the evidence of this Kainozoic faulting, so that I will not enter into the subject at any length. The first record of Kainozoic faulting is due to Selwyn (13), who pointed out the fault line along the eastern shore of Port Phillip. In South Gippsland there is abundant evidence of post-Jurassic fault-

ing, and many of these movements are undoubtedly of Kainozoic age. The Newer Basalts of Victoria are mainly confined to the faulted area of South-Western Victoria. The Great Valley of Victoria is of the nature of a rift-valley, this area having been faulted down since the deposition of the Jurassic rocks. Bass Strait also represents another Kainozoic rift-valley.

The earth movements in Victoria during the Kainozoic period were of the Atlantic coast type, and on Harker's hypothesis we should therefore expect to find rocks of the alkaline branch. It has been shown that such do occur at Macedon (19), Coleraine (23) and Omeo (18), but with them we must associate the calcic basalts.

V. Petrographic Regions.

We are now in a position to criticise Harker's generalisation on the relationship of the alkali and calcic branches of igneous rocks to tectonic movements in the light of the evidence to be derived from a study of the Victorian igneous rocks.

In the first place, notwithstanding Harker's assertion that the characteristics of the two branches are too well known to need recapitulation, there is distinct uncertainty as to which branch a large number of rocks belong. In discussing the basalts of Skye (6) Harker himself finds difficulty in their classification. He considers that normally basalts belong to the calcic group, but that in this case they show alkaline affinities in the presence of various zeolites, including original analcime.

The Heathcotian diabases are probably associated with fault movement, but there is no evidence that they show the slightest sign of alkaline affinities. Zeolites are plentiful in the basalts of Collingwood, Flinders, and elsewhere in Victoria, and anorthoclase is sometimes found to be present, but the few analyses that have been published of the Victorian Kainozoic basalts agree very closely with the composition of basalts from other parts of the world, and there is absolutely no reason for placing them in the alkali branch. Yet these rocks must be associated with fault movements.

In our paper on the Macedon District (19) Professor Skeats and the author advanced evidence in support of the genetic association of the alkaline rocks of that area with the Kainozoic basalts of Victoria. At the same time it was pointed out that similar associations of alkaline rocks with basalts had been recorded by Daly (2) and Marshall (10). If this genetic relationship of alkaline

rocks with basalts be correct, then Harker's generalisation fails unless we assume that the basalts show alkaline affinities.

Turning to the granitic-dacite series of Victoria we see that they are associated with movements of the Pacific coast type, and consequently should be expected to belong to the Calcic Branch.

The analyses of the dacites from Macedon show an average of 2.55 per cent. of potash, 2.62 per cent. of soda, and 4.03 per cent. of lime, so that they must be classed as belonging to the Sub-alkali Group (Iddings), which is equivalent to Harker's Calcic or Pacific Branch.

In the same way the granodiorites may be shown to belong to the Sub-alkali Group.

The analyses of the granites from Dog Rocks, Cape Woolamai, Gabo Island and Mt. Buffalo show the following percentages :—

		Dog Rocks.	Cape Woolamai.	Gabo Island.	Mt. Buffalo.
K_2O	-	5.27	4.76	4.06	4.89
Na_2O	-	3.30	3.00	3.38	3.12
CaO	-	0.41	.65	1.31	0.84

An examination of a section of the granite from the Dog Rocks shows that it contains two felspars, one of which is orthoclase and the other a triclinic form showing exceedingly fine twin lamellae and undulose extinction, and which seems referable to anorthoclase. As this rock contains 8.57 per cent. of alkalies and only 0.41 per cent. of lime, it is quite impossible to stretch the definition of the Calcic Branch to include a rock of this composition. The granites of Cape Woolamai, Mt. Buffalo and Gabo Island must also be classed as belonging to the Alkaline Branch.

The variation diagram (Fig. 3) shows that if any reliance can be placed on variation diagrams, then the alkaline granites are genetically related to the subalkaline or calcic dacites and granodiorites, and that there is a gradual passage from alkaline to calcic types in the granitic-dacite series of Victoria.

It will be seen that the above evidence is in distinct opposition to Harker's generalisation. The calcic diabases of Heathcote and the calcic basalts of the Kainozoic Period are to be associated with movements of the Atlantic coast type and the alkaline granites of the Dog Rocks, Cape Woolamai and elsewhere, accompany movements of the Pacific coast type.

The conclusion then is that Harker's generalisation in its present form fails when applied to the elucidation of the association of igneous rocks and earth movements in Victoria.

VI. The Origin of the Victorian Rock Magmas.

In an earlier portion of this paper evidence has been given for regarding the Heathcotian diabases and the Kainozoic basalts as being associated with trough faulting, while the granites, granodiorites, dacites, etc., were associated with intense earth folding. This means that the basalts, for we may regard the diabases as greatly altered basalts, were associated with one type of tectonic movement, while the granites, etc., were associated with a quite distinct type of movement.

If we turn to the generalised variation diagram (Fig. 4) of the differentiation products of the Victorian granitic magma, we find that the theoretical basic differentiation end product differs radically in composition from normal basalt. This means that a basaltic rock could not be formed as a serial differentiation product from this magma.

In the case of the Macedon alkaline rocks it was shown that some of the rocks were apparently derived by the splitting up of a partial magma, and that the products so formed bore no serial relationship to one another.

In the Geelong and Heathcote districts we have a certain amount of evidence that some of the rocks were derived in a somewhat similar way by the splitting up of a magma.

Westward from Geelong and at the foot of the northern slope of the Barrabool Hills is a large outcrop of a basic rock which is best described as an epidiorite. Intruded through this rock is a well-defined dyke of granite porphyry. The field evidence is such that there is no doubt as to the relative ages of the two rocks.

Northward from this area lies the granite massif of the Dog Rocks. A comparison of sections of this granite with a section of the granite porphyry dyke from the southern area show that except for the difference in the coarseness of grain there is very little distinction between the two, and there is little doubt that they are genetically related. The granite area of the Dog Rocks is roughly triangular in outline, and at the south-eastern corner is an outcrop of epidorite. Microscopically this resembles very closely the epidiorite from the southern area, and again they appear to be genetically related to one another. In this case, however, the epidiorite is apparently intrusive into the granite, and so is younger than that rock. Unfortunately the field evidence is not as conclusive as could be desired, so that the relationship of the two rocks cannot be stated to have been proved. The epidiorite occurs

as an irregular mass on the lower slopes of the Dog Rocks. The two rocks are in no place to be observed actually in contact, but what I have taken for irregular veins of the epidiorite may be traced out into the surrounding granite, but in all cases to no great distance from the main mass. About half a mile to the west, on the southern border of the area, is another small outcrop of epidiorite, but again the relationship is obscured by surface soil. In both cases, however, the epidiorite occurs at a lower level than the general mass of the granite, and as before stated, from the larger area veins of the epidiorite appear to run off from the main mass into the neighbouring granite. Had it not been for the evidence of the southern area I would not have hesitated in concluding that the epidiorite was intrusive into the granite, and as it is this conception accords best with the available evidence. Through the kindness of Mr. E. J. Dunn, analyses of the granite and epidiorite have been made for me by Mr. A. G. Hall at the Mines Department Laboratory. The analysis of the granite has already been quoted, but is given here for comparison with that of the epidiorite, which is recorded for the first time.

TABLE XV.

	I.	II.
SiO_2	75.99	49.25
Al_2O_3	13.10	17.49
Fe_2O_3	0.57	1.25
Feo	0.61	3.95
Mgo	0.18	10.67
Cao	0.41	14.83
Na_2O	3.30	0.75
K_2o	5.27	0.06
H_2O	0.40	1.44
H_2O	0.14	0.14
CO_2	nil.	nil.
Tio_2	0.11	0.09
P_2O5	trace	trace
Mno	0.06	0.09
NiO	0.02	0.02
CoO	trace	trace
BaO	nil.	nil.
Li_2O	trace	trace
Cl.	trace	trace
SO_3	nil.	nil.
Total	100.16	100.03
Sp. Gravity	2.620	2.934

I. Granite, Dog Rocks, Geelong.
II. Epidiorite, Dog Rocks, Geelong.

It will be seen that this analysis of epidiorite, even when re-calculated to 100 per cent., would not conform to the variation diagram of the Victorian Palaeozoic series.

The epidiorite, then, is clearly not related to the granite in a serial manner, and although the evidence is strongly in favour of the two rocks being derived from a common magma, they fail to show any chemical or mineralogical relationship to one another.

It is suggested that these two rocks were derived from a common magma by complementary differentiation, and that the basic differentiation product was intruded to the south, and the acid portion to the north. At the time of intrusion the differentiation was not quite complete, and in the southern area the residual acid portion separated out, and was intruded through the basic portion in the form of a dyke. The irregular character of the junction of the granite and epidiorite at the Dog Rocks suggests the possibility that in this case the completion of the differentiation took place *insitu*.

In the Heathcote area is a somewhat analogous occurrence. The rocks described from this area include diabase, porphyrite, diorite and an acid rock variously called aplite, granophyre, fine-grained granodiorite and micro-granite.

Professor Skeats (14) holds that the micro-granite is genetically related to the diabases and represents an acid residuum from the basic magma.

The diorite is not at all normal, and probably represents a hybrid rock due to a mixing of the diabasic and micro-granitic magmas.

One point of considerable importance is the absence in both cases of normal intermediate types. Harker (4), in discussing the North British Tertiary Province, mentions the occurrence of ultra-basic rocks, the eucrite group, and basic rocks associated with granites and granophyres, but points out that it is a broken series, types of mean acidity being absent.

Another interesting case of the association of acid and basic rocks without the presence of intermediate types is that of the laccolithic sheet of Sudbury, described by Coleman (1) and referred to by Harker (4).

While the latter considers that the separation out of the sulphides from the norites was probably due to the limited miscibility of the sulphide magma with the silicate magma, he doubts whether the separation of the norite from the overlying acid rocks may be attributed to the same cause.

The evidence of the Geelong and Heathcote areas suggest that magmas of intermediate composition have split into two portions, an acid and a basic. We have also seen that a basaltic magma cannot be serially related to the Victorian granite-dacite series. This suggests the hypothesis which is tentatively advanced that wherever a molten magma of intermedite composition exists, whether it be a primary magma or a secondary magma derived by the fusion of pre-existing igneous and sedimentary rocks, then the primary differentiation is into an acid portion and a basic portion, possibly due to the limited miscibility of the two types.

Basaltic magmas appear to have a greater uniformity in composition, and to produce fewer subsidiary types, to which they are serially related, than the magmas which have produced granite, dacite, etc., so that possibly the governing factor in this primary differentiation is the separation out of a basic magma of fairly constant composition.

If this primary differentiation were incomplete, or if by assimilation of other material the balance between the various constituents in the basaltic magma was upset, then secondary differentiation might take place, causing a separation out of a subsidiary magma and leaving a normal basaltic magma.

If the subsidiary magma were molecularly unstable, then further differentiation of the serial or complementary type would be induced, giving rise to a varied facies such as is met with among the Macedon alkaline rocks.

In the case of the acid primary differentiation product, judging by the Victorian examples quoted the various types would be evolved by serial differentiation, with possibly some minor complementary differentiation as at Lilydale.

As in the case of the basic primary differentiation product, if the molecular balance be upset either by incomplete primary differentiation or by assimilation, then a subsidiary magma may separate out and give rise to rocks less normal in character. Basic segregations so common in the Victorian granites may be regarded as possibly representing such subsidiary differentiation caused by the magma assimilating foreign material during intrusion.

As the acid primary differentiation product would have a lower specific gravity than the basic portion, we might expect the acid portion to occupy the upper portion of the primary magma reservoir, and in case of crustal movements, due to lateral compression, might be more affected than the lower basic portion. On the other

hand, faulting would give rise to channels up which the more deeply-seated basic portion might find a passage to the surface. In cases where folding and faulting have accompanied one another we might be expected to get an association of the two types, and in such a case hybrid rocks caused by the mixing of portions of the two magmas might be expected to occur.

VII. Summary.

The aim of the present paper has been to discuss the relationship of certain Victorian igneous rocks and to see what deduction may be made from such study.

The differentiation of several series has been treated at some length, especially with reference to the use of variation diagrams, and it has been shown :—

1. Variation diagrams constructed from analyses which have been recalculated to 100 per cent. with the water omitted and with all the iron converted to ferrous oxide give a better representation of the serial relationship of a group of rocks than diagrams constructed from original analyses.
2. There is an apparent relationship between the shape of the variation curve of the total molecular ratios and the shape of the curves, indicating the serial relationship of the rocks. Thus in the Victorian Upper Palaeozoic series the variation of the total molecular ratios of the recalculated analyses (i.e., the molecular concentration) can be expressed by straight lines, and the variation of the oxides may also be expressed by straight lines. On the other hand the variation of the oxides in the Macedon Kainozoic series must be expressed by means of curved lines in agreement with the curvilinear variation of the molecular concentration.
3. The conception of the complementary differentiation of certain of the Macedon alkali rocks is upheld by the molecular concentration curve. A similar type of differentiation probably accounts for the origin of certain of the Upper Palaeozoic series occurring at Lilydale.

The limits of the differentiation of the Victorian Upper Palaeozoic series are discussed at some length, and it is found that the theoretical acid limit value is a bimineralic compound consisting approximately of 39 per cent. quartz and 61 per cent. alkali felspar, and that the theoretical basic limit value, if we neglect

the iron ores, is also a bimineralic compound containing approximately 41 per cent. of amphibole or pyroxene and 59 per cent. of anorthite.

Harker's generalisation as to the relationship of branches of igneous rocks to tectonic movements is criticised, and evidence is advanced to show that in its present form it fails when applied to Victoria.

The origin of igneous rocks is briefly dealt with, and it is suggested that the primary differentiation of a parent magma is into two portions, a basic and an acidic. The basic portion gives rise to the basalts, gabbros, norites, etc., and the acid or dacitic magma by serial differentiation produces andesites, rhyolites, granites, etc. Other rocks are subordinate in amount and are believed to be due to subsidiary differentiation of a partial magma from the basaltic or dacitic magma when the molecular balance of the latter has been upset by assimilation of foreign material or by incomplete primary differentiation.

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Art. XX.—*Is Eucalyptus fruticetorum, F. v. M., identical with E. polybractea, R. T. Baker?*

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Communicated by Professor A. J. Ewart.

[Read November 13th, 1913].

In this *Journal* xxvi. (New Series), p. 148, is a paper "On *Eucalptus polybractea*, R. T. Baker," by Mr. Baker, in which he gives an account of my endeavours, with imperfect material, some of it of dubious origin, to ascertain the identity of *E. fruticetorum*, F.v.M. Mr. Baker ceased his researches with the year 1910, ending with an imperfect reference to my *Crit. Rev. Eucalptus, ii.*, 40-41.

The actual reference

"On the occasion of a recent (July, 1903) visit to the Melbourne Herbarium I came upon an excellent specimen, bearing a label, entirely in Mueller's handwriting, as follows:—*Eucalyptus fruticetorum*, F. v. M., Lower Avoca (*Wedderburn*) Scrub. W. Percy Wilkinson, 1892."

I had never seen it before, although I had worked on Wilkinson's specimens labelled by the late Mr. J. G. Luehmann, and transmitted by that gentleman to Sydney, and it had probably been mislaid (with many other specimens) in the confusion which took place after Mueller's death. I shall fully figure it in my "Forest Flora of New South Wales" in due course, and it is identical in every respect with type specimens of *E. polybractea*, R. T. Baker.

The type specimen seems to have been lost. I made a personal search in the Melbourne Herbarium for it, with the kind help of Professor Ewart; and no trace of it can be found at Kew, so Colonel Prain is good enough to tell me. There is no good reason to doubt the correctness of Mueller's determination of this characteristic specimen of his own species."

I was not able to carry out my promise as regards my "Forest Flora of New South Wales" until Part XLII, 28 (1911), through circumstances beyond my control, but no one has been prejudiced in any way by the delay.

The twig of *E. fruticetorum* F.v.M. that I depicted at Plate 156 of my *Forest Flora* was faithfully drawn, as anyone can see by referring to the original in the Melbourne Herbarium.

Mr. Baker (*op. cit.* p. 148) states that he was shown a specimen bearing Mueller's label, "*E. fruticetorum*," but does not quote the further particulars on that label. Perhaps it was Mr. W. Percy Wilkinson's specimen. I repeat that that specimen was labelled by Mueller *E. fruticetorum* in 1892. I further say that this specimen is identical with a plant which Mr. Baker believed to be new in 1900, and named by him *E. polybractea.*

If these two statements of mine are wrong, Mr. Baker should point out the error or errors, and I will gladly withdraw them. I have bestowed much care on the elucidation of Mueller's *E. fruticetorum*, and, since 1908 believe that finality has been attained.

At p. 149 Mr. Baker says Mueller's description of *E. fruticetorum* is too meagre upon which to place any systematic work, yet at p. 150 he assumes (parallel columns) that the contrary is the case.

I have done my very best to ascertain the species-names of the older workers in Eucalypts, and have revived more than one name from unmerited oblivion.

Having found Mueller's *fruticetorum* (not the type, for that is lost, but the next best thing, a specimen certified by the describer), all the previous surmises, founded on imperfect and even doubtful material, give way (as far as I am concerned) to my latest pronouncement. A botanist has a right, like any other person, to be judged by his latest decision.

Mr. Baker's criticism is entirely negative as regards *E. fruticetorum;* he does not make a single suggestion as to what it may be, but leaves it a name, in spite of Mueller's own identification of it.

In passing, let me say that one must not apply the microscope too closely to the descriptions of Eucalyptus species by the older botanists. (Surely the same thing applies to other groups of plants and animals). One must try and find out what they meant; what they did not mean is less important. On more than one occasion when in conversation I confronted Mueller with difficulties of this kind, he gave his ruling, and added, "We must read descriptions philosophically"—a favourite word of his.

He obtained a great acquisition of Eucalyptus material at the time he wrote the description of *E. fruticetorum*, namely, during the writing of the second volume of the *Fragmenta*. The confusion he made with his *E. hemiphloia* (see *Fragm.* ii. 62, and also my *Crit. Rev.* ii., 14), is an extreme case.

Smith confused both his *E. resinifera* and *S. piperita,* but years afterwards, Smith being dead, and the types lost, Bentham

gave his interpretation of them, without introducing an additional name, and no one has ever disputed his decision. He has not even a Smith-named specimen, type or no type. I could give other examples.

Mr. Baker, at p. 151, points out that the Blue Mallee of Victoria (Inglewood, etc.), and of New South Wales (Wyalong) are identical, which is what I pointed out in my "Forest Flora of New South Wales," in 1911. Indeed, I have also shown that it extends to South Australia.

To Mr. Baker's appeal to drop the name *fruticetorum* because some distillers are selling its oil under the name *E. polybractea*, I have nothing to say, except that our efforts should be in the direction of ascertaining the correct name as regards every species. The correct name, when ascertained, will stand for all time, and the sooner such is ascertained the sooner we shall arrive at stability of nomenclature, which is surely the aim of all careful taxonomists.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Part II., 1914.]

Art. XXI.—*Description of New and Rare Fossils obtained by Deep Boring in the Mallee.*

Part II.—Mollusca.

BY

F. CHAPMAN, A.L.S.

(Palaeontologist to the National Museum),

AND

C. J. GABRIEL.

(With Plates XXIV.-XXVIII.)

[Read 13th November, 1913].

MOLLUSCA.

Class PELECYPODA.

Fam. NUCULIDAE.

Genus NUCULA, Lamarck.

Nucula obliqua, Lamarck.

Nucula obliqua, Lamarck, 1819, Anim. sans Vert., vol. vi., pt. i., p. 59. Hedley, 1902, Mem. Austr. Mus. Sydney, No. iv., p. 292.

In the present borings *N. obliqua*, Lamarck is represented by some identifiable fragments and one perfect valve. The latter, together with numerous specimens in the Dennant collection, bears out our conclusion that in the oldest of our Tertiary beds the ancestors of the living species are represented by a more depressed shell, of thinner build, and more acute at the umbones; intermediate forms are found in the Janjukian series at Table Cape; whilst in the Kalimnan beds of Grange Burn and elsewhere, the same species had already attained characters seen in the living *N. obliqua*.

Distribution.—Bore 8, 165-180 feet, Bore 9, 254-256 feet.

Fam. LEDIDAE.

Genus LEDA, Schumacher.

LEDA HUTTONI, T. Woods.

Leda huttoni, T. Woods, 1878, Proc. Linn. Soc. N.S. Wales, vol. iii. pl. xxi. fig 2, Tate, 1886, Trans. R. Soc. S. Austr. vol. viii. p. 130, pl. vi. fig. 4.

A single, rather worn, but nevertheless undoubted valve of the above species occurs in the Mallee borings. In examining this specimen, together with numerous examples of *L. huttoni*, in the Dennant collection, we are struck with the close morphological affinities of his species with *L. lefroyi*, Beddome, living on the southern Australian coasts. It only materially differs from that species in the more regularly convex ventral margin and heavier dentition.

Distribution.—Bore 8, 165-180 feet.

Fam. PARALLELODONTIDAE.

Genus CUCULLAEA, Lamarck.

CUCULLAEA CORIOENSIS, McCoy.

Cucullaea corioensis, McCoy, 1876, Prod. Pal. Vict., dec. iii. p. 32, pl. xxvii., figs. 3, 4, 5*a*, *b*.

In the examination of some fragments of heavy examples we note a uniformity in the Mallee specimens, in that they show the transverse undulose ornament with the convexity on the radial ribs pointing towards the ventral margin. The two heaviest specimens figured by McCoy show the same feature, whilst the remainder and those from Muddy Creek in the Dennant collection exhibit a similar ornament, but with the undulations directed to the dorsal margin.

Distribution.—Bore 8, 199-204 feet. Bore 9, 263-273 feet; 315-325 feet.

Fam. ARCIDAE.

Genus LISSARCA, E. A. Smith.

LISSARCA RUBRICATA, Tate sp.

Limopsis rubricata, Tate, 1887, Trans. Roy. Soc. S. Austr., vol. ix., p. 71, pl. v., fig. 6.

Lissarca rubricata, Tate sp., Verco, 1907, Trans. Roy. Soc. S. Austr., vol. xxxi. p. 221, Gatliff and Gabriel, 1908, Proc. Roy. Soc. Vict. vol. xxi. (N.S.), pt. I. p. 390.

A typical valve of this species was found associated with fossils of a Kalimnan facies in the Mallee bore. The present specimen has been carefully compared with living examples from the Victorian coast, and found to be identical in the minutest particulars.

Distribution.—Bore 2, 198-200 feet.

Genus GLYCIMERIS, da Costa.

GLYCIMERIS MACCOYI, Johnston sp. (Plate XXIV., Figs. 1-5).

Pectunculus laticostatus, McCoy, non Quoy and Gaimard, 1875, Prod. Pal. Vict. dec. ii., p. 26, pl. xix., figs. 10-14.

P. M'Coyi, Johnston, 1885, Proc. R. Soc. Tas. for 1884, p. 199.

P. McCoyii, Johnston, Tate, 1886, Trans. R. Soc. S. Austr., vol. viii. p. 137.

From a lengthy and minute examination of numerous specimens of the above species from Balcombian, Janjukian and Kalimnan strata, we are able to make the following observations. The examples afford an interesting study of a series of mutations of one species through a comparatively long geological epoch, which species meantime preserves its essential characters.

1. The fossil specimens figured by McCoy under the name of *Pectunculus laticostatus*, Quoy and Gaimard, represent the tolerably distinct mutations (in Waagen's sense) of the one form. They are:—

Form *a.*—A small shell from Grice's Creek (Balcombian): length (ant.-post.), 14.75 mm.; height, 14 mm. (Pl. xxiv., fig. 1). Also larger valves from Corio Bay (Janjukian), length, 42.25 mm.; height, 42 mm. Characterised by 32 riblets in the small shell and by 34 riblets in the large one.

Form *b.*—A large and ponderous shell from Bird Rock (Janjukian): length, 64 mm.; height, 67 mm. Characterised by 40 riblets, practically equal to that of the recent *Glycimeris laticostatus*, Q. and G. (Pl. i. figs. 2, 3.)

2. The typical form of *G. maccoyi* diagnosed by R. M. Johnson has 29 riblets. (Pl. xxiv. f. 4.) His type form was described from the Table Cape beds (Janjukian); a similar form, but smaller, is found in the Balcombian of Mornington, Muddy Creek older beds, and the younger series at Corio Bay.

3. Accompanying the typical *G. maccoyi* at Table Cape (ex Atkinson coll. in the National Museum, Melbourne), are shells in every way comparable with the form approaching *G. laticostatus*, Q. and G., and figured by McCoy from Bird Rock. This we refer to form *b* (*antea*).

4. The several mutations of the above species show it to commence in the Balcombian as a moderate-sized shell with about 29 riblets, persisting into the Janjukian. Side by side with this form the mutation *b* springs up, but disappears before the Kalimnan.

5. The Kalimnan variant (form *c*) resembles the Balcombian (small var.) species, but is even smaller, and retains the Janjukian character of form *b* in having a more deeply concave umbonal cavity. (Pl. xxiv. fig. 5.) Its archaic character is seen in the number of its riblets, 26-30 (F.C. coll. in Nat. Mus. Melb. from MacDonald's, Muddy Creek).

6. The Bird Rock and Table Cape variant, form *b*, is clearly the Janjukian ancestor of *G. laticostatus*, Q. and G. (*forma vera*), which later on inhabited the Pliocene sea at Wanganui, and is now[1] confined to the area round New Zealand and the Chatham Islands. From *G. laticostatus*, Q. and G., the form *b* of Table Cape and Bird Rock differs in having a longer shell (ant.-post.) and a more finely striated ligamental area. (Pl. xxv. fig. 6.)

7. In the Kalimnan series *G. maccoyi* merges into *G. subtrigonalis*, Tate,[2] by the truncation of the anterior cardinal angle.

All the specimens of *G. maccoyi* from the Mallee bores belong to form *a*, having fewer riblets and moderate dimensions.

Distribution.—Bore 5, 162-163 feet; 175-189 feet. Bore 6, 158-161 feet. Bore 8, 165-180 feet; 199-204 feet; 204-210 feet. Bore 9, 254-256 feet.

Fam. TRIGONIIDAE.

Genus TRIGONIA, Bruguière.

TRIGONIA LAMARCKI, Gray. (Pl. XXV., Figs. 7-9).

Trigonia lamarckii, Gray, 1838, Ann. and Mag. Nat. Hist., vol. I., p. 482, Reeve, 1860, Conch. Icon. vol. xii. pl. i., figs 1*a*-*c*. T. Woods, 1888. (Journ. Roy. Soc. N.S. Wales, vol. xxii.), p. 163, pl. x. figs. 16, 17; pl. xiv. figs. 25, 26.

1. Typical examples of *G. laticostatus*, Q. and G. sp., from the Wanganui beds of N. Zealand, are in the Melbourne National Museum.

2. Trans. R. Soc. S. Austr., vol. viii. (for 1884-5), 1886, p. 137, pl. xi., figs. 6*a*, *b*.

A solitary example of the above species was found in the Mallee material. It is quite typical both in the costate ornament with blunt processes and in the heavy character of the shell. It is most interesting to meet with this species, which has not been recorded south of Port Jackson as a living shell, for it occurs here in presumably passage beds between the Janjukian and Kalimnan series of the Mallee.

A well-known Kalimnan offshoot of this polyphyletic form of *Trigonia* is seen in *T. howitti* McCoy, which has the same ornament (see pl. xxv. fig. 10), but is stouter, heavier and with fewer ribs; a form more adapted to shore conditions, as denoted by the fauna accompanying that shell.

Distribution.—Bore 9, 315-325 feet.

TRIGONIA MARGARITACEA, Lamarck, var. ACUTICOSTATA, McCoy.
(Pl. XXVI., Figs. 12 and 13*a*, *b*).

Trigonia acuticostata, McCoy, 1866, Geol. Mag. vol. iii. pp. 481, 482, fig. 1. Idem. 1875, Prod. Pal. Vict. dec. II., p. 21, pl. xix., figs. 1, 2. *T. margaritacea*, Lam. var. *acuticostata*, McCoy, Hedley, 1902, Mem. Austr. Mus., Mem. IV. pt. 5, p. 301, figs. 47, 48.

McCoy, in his original description of the above fossil, alludes to the distinction between this variant of *T. margaritacea*, Lam. and the species, *T. lamarcki*, Gray, and *T. pectinata*, Lam. (=*T. margaritacea*) in having a "remarkable compression of the ribs into acute angular ridges; and from the same cause the spinous tubercles do not form the broad, blunt, transverse tubercles which they do in the recent species, in which latter the ridges form broad, obtusely flattened, almost square ribs when viewed from the margin in a position in which those of the present species form a series of acute angles."[1]

That this distinction is only varietal has already been pointed out by Mr. Hedley (loc. supra cit. p. 301), who is not followed in this, however, by Messrs. Pritchard and Gatliff.[2] The fossil examples correspond with the living *T. margaritacea* (see pl. xxv. fig. 11), in having a lighter and less inflated shell as compared with *T. lamarcki*; also in being more oblique and having more acute ribs. It is never found lower than the Kalimnan series (Lower Pliocene) in the geological scale.

1. Loc. cit., 1875, p. 22.
2. Proc. Roy. Soc. Victoria, vol. xvi. (n.s.), pt. i., 1904, pp. 235-237. See also Pritchard, Vict. Nat., vol. xxiii., w. 6, 1906, p. 118.

The recent examples of *T. margaritacea*, var. *acuticostata* from Bass Strait determined by McCoy have all the requisite characters of the fossil variety, and specimens in the Dennant collection from Jemmy's Point exactly resemble them in the fewer number of ribs. (See pl. xxvi. figs. 13*a*, *b*.

T. margaritacea has been recorded from the Werrikooian (Pleistocene) of Limestone Creek, Glenelg River, by Mr. J. Dennant.[1] On referring to the Dennant collection, however, we find the only specimen of *Trigonia* from Limestone Creek there represented belongs to *T. lamarcki*.

A variety of *T. margaritacea*, in which the scales of the ribs are flattened out in an almost spatulate fashion, has lately been described by Dr. J. C. Verco, from St. Vincent's Gulf, and elsewhere along the South Australian shores, to which he gives the varietal name, *bednalli*.[2]

Distribution.—Bore 2, 198-200 feet. Bore 3, 226 feet. Bore 6, 154-158 feet; 158-161 feet. Bore 9, 315-325 feet. Bore 10, 230-254 feet; 254-296 feet.

Fam. PECTINIDAE.

Genus PECTEN, Müller.

Pecten murrayanus, Tate.

Pecten murrayanus. Tate, 1886, Trans. R. Soc. S. Aust., vol. viii. p. 105, pl. vii. figs. 5*a*, *b*.

This species affords an interesting illustration of the close relationship between many of our Tertiary species of mollusca and those now living, generally in lower latitudes, around the Australian coast and in the adjacent seas. *P. murrayanus* is clearly a progenitor of the group of pectens represented by *P. leopardus* Reeve[3] (W. and N. Australia and New Caledonia); *P. solaris*, Born sp.[4] (China Seas and Amboyna); and *P. kuhnholtzi*, Bernardi[5] (New Caledonia). In all four species, the costation and concentric ornament are precisely identical, if a fairly extensive series is taken. A constant character in all is shown in the crowding of the concentric lamellae near the umbonal region, their opening out

1. Rec. Geol. Surv. Vict., vol. i., pt. ii., 1903, p. 146.
2. Trans. Roy. Soc. S. Austr., vol. xxxi., 1907, p. 224, pl. xxviii., figs. 1-3.
3. Icon. Conch, 1852, pl. xxxii., fig. 145.
4. Index Mus. Caes. Vind., 1778, pt. i., Testacea, pl. vi., fig. 4. See also Sowerby, Thes. Conch. 1842, pt. ii., p. 55, pl. xii., figs. 7, 8, 22.
5. Journ. de Conch., 1863, vol. viii., p. 378, pl. xiii., fig. 1.

in the medium area, and dense condition repeated in the ventral area. The above conclusions have been arrived at after a prolonged study of the living shells above noted.

Distribution.—Bore 1, 215-244 feet. Bore 3, 226 feet. Bore 4, 163-170 feet. Bore 5, 162-163 feet; 175-189 feet.

Fam. MYTILIDAE.

Genus ARCOPERNA, Conrad.

ARCOPERNA SCAPHA, Verco. (Pl. XXVII., Fig. 16).

Arcoperna scapha, Verco, 1908, Trans. Roy. Soc. S. Aust. vol. xxxii. p. 196, pl. xii. figs. 1-5.

Observations.—A typical example of this species, in no wise differing from the living form, occurs in the present series. It is the first recorded occurrence of this genus as an Australian fossil. The species is well-known as a recent form by Dr. Verco's published description; that author recording it from Beachport at 49 to 200 fathoms; off Cape Jaffa, 90 and 130 fathoms; off Cape Borda, 55 fathoms; and east of Neptunes, 45 fathoms, all in S. Australia. Dr. Verco's record of Mr. Hedley's report of the species in New South Wales is 22 miles east of Narrabeen, at 80 fathoms. One of us (C.J.G.) has obtained it off Wilson's Promontory.

In the Dennant collection specimens labelled "*Verticordia* sp." can be referred to this genus. They are from Brown's Creek, Spring Creek and Hamilton Creek, Janjukian localities which may be on the same or a lower horizon than the present specimen which is associated with a mixed Kalimnan and Janjukian fauna. The shells from the undoubted Janjukian localities mentioned, differ however, in the stronger decussate surface ornament and rough growth-lines, and probably represent another species.

Distribution.—Bore 3, 226 feet.

Fam. CRASSATELLITIDAE.

Genus CRASSATELLITES, Kruger.

CRASSATELLITES KINGICOLOIDES, Pritchard.

Crassatellites kingicoloides, Pritchard, 1902, Proc. Roy. Soc. Vict., vol. xv. (N.S.) pt. i. p. 94, pl. xiii. figs. 1-3. IV. pt. 5, p. 315, woodcut, fig. 55.

Up to the present this species has only been recorded from the Gippsland Lakes Tertiary deposits at Jemmy's Point, It has, how-

ever, been identified by us in the Nat. Mus. collection from Beaumaris.

In the Mallee borings the species is fairly abundant at the Kalimnan horizon, associated with such typical fossils as *Limopsis beaumariensis*, Chapm. and *Bathyactis beaumariensis*, Dennant.

A point worthy of special remark is the absence from the boring material in the Mallee, of the allied form, *Crassatellites camurus*, Pritchard[1]; a species which was described from the Western District of Victoria (Grange Burn and McDonald's, near Hamilton), and, so far as we know, has not occurred elsewhere. This alliance of the fauna with the Jemmy's Point facies of the Kalimnan, rather than with that of the shallow-water facies of the Hamilton District (Upper beds), is further borne out by the occurrence in the Mallee of *Turritella pagodula*, a common Jemmy's Point fossil.

Even in fragments it is tolerably easy to distinguish *C. kingicoloides* from *C. camurus* by the relatively greater depth in the former of the posterior adductor impression, and, what is even more striking, the large, deep and broad lunule and its transversely striated character as compared with *C. camurus*.

Distribution.—Bore 1, 208-210 feet. Bore 2, 198-200 feet. Bore 3, 226 feet. Bore 4, 163-170 feet. Bore 5, 155-159 feet; 175-189 feet. Bore 6, 154-158 feet. Bore 8, 199-204 feet; 204-210 feet. Bore 9, 263-273 feet; 315-325 feet. Bore 10, 254-296 feet; 310-320 feet.

Genus CUNA, Hedley.

Cuna concentrica, Hedley.

Cuna concentrica, Hedley, 1902, Mem. Austr. Mus., Mem. iv. pt. 5, p. 315, woodcut, fig. 55.

The above species, first described by Mr. Hedley from shells found in dredgings off the coast of New South Wales, shows certain variations within limits; but the chief characters are so distinct that there is no difficulty in matching it with our fossils from the Mallee bores at the Kalimnan horizon (L. Pliocene).

The living specimens have been recorded from Port Kembla, 63-75 fathoms, by C. Hedley; and from Balmoral Beach, shore-line, by one of us (C.J.G.). Both localities are in N.S. Wales.

Cuna edentata, Verco,[2] living in the Gulf of St. Vincent, S Australia, resembles the above species in both fossil and recent

1. Loc. supra cit., 1902, p. 96, pl. xiv., figs. 5-9.
2. Trans. Roy. Soc. S. Austr., vol. xxxii., 1908, p. 357, pl. xiv., figs. 1-3.

examples, with the distinction, however, that the denticulations on the inner ventral border in *C. concentrica* are wanting in Verco's species.

Distribution.—Bore 8, 204-210 feet. Bore 9, 263-273 feet. Bore 11, 175-197 feet; 197-199 feet.

Fam. CONDYLOCARDIIDAE.

Genus CONDYLOCARDIA, Bernard.

CONDYLOCARDIA TENUICOSTAE, sp. nov. (Pl. XXVII., Figs. 17*a-c*).

Description.—Shell very small, shining, of a cream colour. Ovate wedge-shaped, inequilateral; inflated at the umbonal region and depressed towards the ventral. Dorsal margin straight; anterior end tapering and bluntly rounded at the ventral angle; posterior end short and widely rounded towards the ventral. Interior of shell smooth, with feeble muscular impressions; ventral edge on the commissure bearing a series of minute depressions and elevations, passing into thin, diminishing riblets within.

External surface sculpture consisting of about 36 narrow, depressed or sub-acute riblets, slightly varying in strength and dying out before reaching the umbonal area; crossed at irregular intervals by several well-marked concentric growth-lines.

Cardinal border, short, straight, Left valve with a strong bifid, median cardinal tooth, and feeble anterior and posterior lateral teeth; right valve with a triangular anterior cardinal, behind which is a deep fossa for the median cardinal of the left valve.

Prodissoconch smooth, subovate, slightly salient post-ventrally; umbonal aspect depressed.

Dimensions.—Holotype (left valve) from Bore 10, 310-320 feet. Length, 2.15 mm.; height, 1.77 mm.

Observations.—This species is a very distinct form. It shows some relationship to *Condylocardia pectinata*, Tate and May sp.[1] in its general form and hingement, but in that species the ornament is a coarse radial ribbing instead of fine costulations, as in *C. tenuicostae*.

Distribution.—Bore 8, 225-226 feet. Bore 10, 186-190 feet; 225-230 feet (paratype); 310-320 feet (holotype). Bore 11, 175-197 feet; 197-199 feet.

1. *Carditella pectinata*, Tate and May, Trans. Roy. Soc. S. Austr., vol. xxiv., 1900, p. 103. Proc. Linn. Soc. N. S. Wales, vol. xxvi., 1901, p. 435, pl. xxvii., figs. 96, 97. See also Hedley, Rec. Austr. Mus., vol. vii., No. 2, 1908, pl. xxv., figs. 43-45.

Fam. CARDITIDAE.

Genus CARDITA, Brubudière.

CARDITA CALVA, Tate. (Plate XXVII., Fig. 18).

Cardita calva, Tate, 1887, Trans. Roy. Soc. S. Austr., vol. ix. p. 189, pl. xx. fig. 14.

This species is not found below the Kalimnan series. As Tate remarks, it is nearest allied to *C. compacta*, but is distinguished by the smooth umbones, and it also slightly differs in shape.

C. calva is very abundant in the younger beds in the Mallee bores, and shows a surprising amount of variability in the surface ornament. One of the extreme forms is now figured, in which the cancellate ornament, produced by the crossing of the concentrics by the radials is confined to a narrow strip on the posterior margin.

This species is found graduating into *Cardita dilecta*, var. *excelsior*, Verco,[1] a living Australian form; some specimens of the fossils matching it so closely as to be inseparable.

Distribution.—Bore 1, 215-244 feet. Bore 3, 201-220 feet; 226 feet. Bore 5, 163-175 feet. Bore 6, 114-150 feet; 158-161 feet. Bore 8, 165-180 feet; 210-219 feet. Bore 9, 254-256 feet; 263-273 feet; 315-325 feet. Bore 10, 230-254 feet. Bore 11, 197-199 feet.

CARDITA SPINULOSA, Tate.

Cardita spinulosa, Tate, 1886, Trans. Roy. Soc. S. Aust., vol. viii. p. 153, pl. ii. fig. 3.

This species is evidently very closely related to *Carditella torresi*, E. A. Smith,[2] which, by the way, according to that author, is not typical of the genus *Carditella*, in its ligamental characters.[3] The only difference between the recent species quoted and our fossil specimens appear to be in the lighter hinge area of the living form.

Cardita spinulosa, Tate, is represented in the bore by small specimens of the normal subrotund shape of the neanic examples, as distinguished from the ventrally truncated forms in the gerontic stage.

Distribution.—Bore 3, 226 feet. Bore 6, 158-161 feet. Bore 10, 310-320 feet.

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1. *Venericardia dilecta*, E. A. Smith, var. *excelsior*, Verco, Trans. Roy. Soc. S. Austr., vol. xxxii., 1908, p. 348, pl. xiv., fig. 9. *Cardita calva*, Tate. Gatliff and Gabriel, Proc. Roy. Soc. Victoria, vol. xxv, (n.s.), pt. i., 1912, p. 173.
2. Rep. Chall. Zool., vol. xiii., Lamellibranchiata, p. 217, pl. xv., figs. 8. 8a.
3. Loc. supra cit., p. 218.

Fam. LEPTONIDAE.

Genus ROCHEFORTIA, Velain.

ROCHEFORTIA DONACIFORMIS, Angas sp.

Mysella donaciformis, Angas, 1878, Proc. Zool. Lond., p. 863, pl. liv. fig. 13.

Rochefortia donaciformis, Angas, sp., Dall. 1900, Trans. Wagner Inst., vol. iii. pt. 5, p. 1157. Hedley, 1902, Proc. Linn. Soc. N.S. Wales, vol. xxviii. pt. i. p. 7, pl. i. figs. 10-14.

This species is recorded as living on the coasts of Victoria, Tasmania and N.S. Wales. Our specimens are identical in all essential points of shape, ornament and hingement, with the recent specimens.

Distribution.—Bore 11, 542-544 feet; 544-546 feet.

Genus ERYCINA, Lamarck.

ERYCINA MICANS, Tate sp.

Kellia micans, Tate, 1887, Trans. Roy. Soc. Vict., vol. ix. p. 148, pl. xix. fig. 13.

This common Kalimnan fossil is generically related to the living Erycinas of the Australian coast. It closely approaches *Kellia angasiana*, Tate,[1] a form which may eventually find its place in the above genus, from which it differs in the stronger cardinal dentition and usually present concentric ornament.

In Kellia the hinge is lighter and the shell non-punctate. The shell in Lepton is typically more depressed and the hingement is slighter.

The living *Erycina parva*, Deshayes,[2] has a similar shell, but with a more convex ventral border; the valve-surface, moreover, is conspicuously pitted instead of microscopically so, as in *E. micans*. The dentition is identical with that of *E. micans*.

The related *E. parva* has been found fossil in the Pliocene of Wanganui, N. Zealand, by R. Murdoch,[3] and as a living species is found in New Zealand, Victoria and N.S. Wales.

1. Trans. Roy. Soc. S. Austr., vol. ix. (1886), 1887, p. 68, pl. v., fig. 7.
2. *Kellia parva*, Deshayes, Proc. Zool. Soc. Lond., 1855, p. 182. *Erycina acupuncta*, Hedley, Mem. Austr. Mus., No. iv., pt. 5, 1902, p. 321, woodcut fig. 60. *Erycina parva*, Desh. sp., Hedley Trans. N. Z. Inst., vol. xxxviii., 1905, p. 73.
3. See Hedley, loc. supra cit., p. 74.

Distribution.—Bore 6, 114-150 feet. Bore 7, 142 feet 3 inches-155 feet. Bore 10, 225-230 feet; 310-320 feet. Bore 11, 197-199 feet.

Fam. DONACIDAE.

Genus DONAX, Linné.

DONAX KENYONIANA,[1] sp. nov. (Pl. XXVII., Figs. 19*a*, *b*, 20 and 21.)

Description.—Shell, triangularly elongate-ovate, very inequilateral, the anterior extremity being much larger than the posterior; depressed convex, flattened towards the ventral and anterior, and with a distinct depressed area on the ventral behind the median line; ventral margin nearly straight, incurved near the keel; antero-ventral angle well rounded, posterior sub-angulate; umbonal keel elevated and sharp. Surface of shell with purple and cream colour-bands in well preserved specimens. Growth-lines conspicuously marked, crossed by fine, radial striae, stronger towards the posterior. Interior of shell smooth, with the commissure raised within and flattened towards the outer margin, in clean specimens closely and finely vertically striated.

Dimensions.—Length of holotype (medium-sized example), 12 mm.; height, 7.75 mm. Length of a larger specimen, paratype, 33.75 mm. Shell sometimes attaining a length of about 33 mm.

Observations.—The above species differs from *Donax depressa*, Tate,[2] a Murray cliffs fossil, in its more elongate form and striated inner margin. In the latter character it resembles *D. deltoides*, Lamarck,[3] a species still living on the Victorian coast, but from which it is at once separated by its greater length and thinner build.

Distribution.—Bore 7, 142 feet, 3 inches-155 feet. Bore 8, 160-165 feet; 165-180 feet. Bore 10, 186-190 feet; 195-225 feet; 225-230 feet; 310-320 feet.

Fam. CORBULIDAE.

Genus CORBULA, Lamarck.

CORBULA COXI, Pilsbry.

Corbula coxi, Pilsbry, 1897, Proc. Acad. Nat. Sci. Philad., p. 363, pl. ix. figs. 1-3. *C. scaphoides*, Dennant and Kitson, non Hinds, 1903, Rec. Geol. Surv. Vict., vol. i. pt. 2, p. 139. *C. coxi*, Pilsbry, Gatliff and Gabriel, 1909, Proc. Roy. Soc. Vict., vol. xxii. (N.S.) pt. i. p. 44.

1. Named after Mr. A. S. Kenyon, of the State Rivers and Water Supply Commission.
2. Trans. R. Soc. S. Austr., vol. ix., 1887, p. 168, pl. xvi., fig. 11.
3. Anim. sans Vert. (ed. Deshayes), vol. vi., 1819, p. 241. Pritchard and Gatliff, Proc. R. Soc. Vict., vol. xvi. (N.S.) pt. i., 1903, p. 118.

In working out the several species of *Corbula* occurring in the Mallee bores, it was discovered that a discrepancy exists regarding the identity of the Kalimnan species found at Grange Burn and other localities, which has hitherto been referred to Hinds' species *C. scaphoides*. The latter species, a figure of which is given in the Challenger Report,[1] is, however, a high, strongly umbonate form with deep sulci, generally comparable with *C. ephamilla*, Tate,[2] but not so heavily structured.

One of us (C.J.G.), in writing to Mr. E. A. Smith, of the British Museum, has had the benefit of that gentleman's dictum regarding the Victorian species, *C. coxi*, Pilsbry, which Mr. Smith recognised amongst specimens sent to him, and which he compared with typical specimens in the British Museum (Nat. History), London. These specimens have been carefully studied in comparison with some of ours from the Mallee bores, which show them to be identical; and at the same time agreeing with specimens in the Dennant collection from the Victorian Kalimnan, determined by that author as *C. scaphoides*, Hinds.

Distribution.—Bore 1, 215-244 feet. Bore 3, 266 feet. Bore 4, 163-170 feet. Bore 5, 155-159 feet; 163-175 feet; 175-189 feet. Bore 6, 114-150 feet; 158-161 feet. Bore 8, 165-180 feet; 180-199 feet; 204-210 feet; 210-219 feet. Bore 9, 254-256 feet; 263-273 feet; 315-325 feet. Bore 10, 160-186 feet; 186-190 feet; 225-230 feet; 230-254 feet; 254-296 feet; 310-320 feet.

Corbula ephamilla, Tate.

Corbula ephamilla, Tate, 1887, Trans. Roy. Soc. S. Aust. ol. ix. p. 176, pl. xii. figs. 13*a*, *b*, 14.

In the course of diagnosing the differential characters of the *Corbulae* in the Mallee borings, the close relationship of *C. tunicata*, Hinds,[3] to the above species was very apparent. The only difference being the usually heavy, incrassate character of the shell cavity of the anterior area.

The true *C. scaphoides*, Hinds,[4] is also extremely close, both in shape and ornament, when the adult shells are compared; the chief

1. Hinds, Proc. Zool. Soc. Lond., pt. xi., 1843, p. 56. E. A. Smith, Rep. Chall., Zool. vol. xiii., pt. xxxv., 1885, p. 32, pl. vii., figs. 3, 3*a*, 3*b*.
2. Trans. Roy. Soc. S. Austr., vol. ix., 1887, p. 176, pl. xvii., figs. 13*a*, *b*, 14.
3. Proc. Zool. Soc. Lond., 1843, p. 55.
4. Cf. E. A. Smith, loc. supra cit.

differences being the usually heavy and thickened structure of the shell in *Corbula ephamilla*, along with the greater attenuation of its anterior.

Distribution.—Bore 1, 208-210 feet. Bore 3, 226 feet. Bore 4, 163-170 feet. Bore 5, 155-159 feet; 162-163 feet; 175-189 feet. Bore 6, 114-150 feet; 150-154 feet; 154-158 feet; 158-161 feet. Bore 7, 142 feet 3 inches-155 feet. Bore 8, 165-180 feet; 180-199 feet; 199-204 feet; 204-210 feet; 210-219 feet. Bore 9, 254-256 feet; 263-273 feet; 315-325 feet. Bore 10, 220 feet; 254-296 feet; 310-320 feet. Bore 11, 199,209 feet.

Class SCAPHOPODA.

Fam. DENTALIIDAE.

Genus DENTALIUM, Linné.

DENTALIUM ARATUM, Tate.

Dentalium aratum, Tate, 1887, Trans. Roy. Soc. S. Austr., vol. ix. p. 192, pl. xx. fig. 8, Idem, ibid., 1889, vol. xxiii. p. 265.

A critical examination of the recent related forms of the above genus has resulted in the following conclusions:—The Australian *Dentaliidae* form a large group, the characters of which show a great amount of variation. *D. aratum* is no exception, and the species most likely to be confused with that form are the living *D. robustum*, Brazier,[1] *D. intercalatum*, Gould,[2] and *D. francisense*, Verco.[3] *D. robustum* can be separated by the absence of longitudinal striae. A constant feature of the costation in *D. intercalatum* is in the ribs becoming distinctly rounded in later growth. In the case of *D. francisense* we agree with Verco, who remarks, "I am inclined to think that even this species is but an extreme variant of the *D. intercalatum*, Gould."

Distribution.—Bore 1, 215-244 feet. Bore 3, 226 feet.

1. Proc. Linn. Soc. N.S. Wales, vol. ii., 1877, p. 56. Hedley Rec. Austr. Mus., vol. iv., No. 3, 1901, p. 128, pl. xvii., fig. 32.
2. Proc. Bost. Soc. Nat. Hist., vol. vii., 1859, p. 166. Sowerby in Reeve's Icon. Conch, vol xviii., 1872, pl. vii., fig. 45.
3. Trans. Roy. Soc. S. Austr., vol. xxxv., 1911, p. 207, pl. xxvi., figs. 1, 1*a*.

Fam. SIPHONODENTALIIDAE.

Genus CADULUS, Philippi.

CADULUS ACUMINATUS, Tate.

Cadulus acuminatus, Tate, 1887, Trans. Roy. Soc. S. Aust., vol. ix. (for 1885), p. 194, Idem, 1899, ibid., vol. xxiii. (for 1898-9), p. 266, pl. viii. fig. 12.

Observations.—This species is separated from *C. infans*[1] by some slight characters, which are nevertheless constant. It is an interesting point with regard to the above species that as a fossil, *C. acuminatus* is confined to the Lower Pliocene (Kalimnan) or "Oyster beds" of Aldinga, whilst *C. infans* is only found at Muddy Creek, in beds of the same age. This is an additional proof of the relationship of the Mallee Cainozoic marine fauna with the rest of the Murray Gulf occurrences, for the Hamilton Kalimnan sea appears to have been partially shut off from the former by the porphyry and granite cliffs of south-western Victoria.

C. acuminatus is found living around the coasts of New South Wales, Victoria and South Australia.

Distribution.—Bore 11, 175-199 feet.

Class GASTEROPODA.

Fam. DELPHINULIDAE.

Genus LIOTIA, Gray.

LIOTIA DENNANTI, sp. nov. (Plate XXVII., Figs. 22, 23).

Description.—In form somewhat trochoid, consisting of four whorls; the first two somewhat depressed with a slightly discernible fine medium keel, becoming more pronounced in the third and fourth whorls; the last whorl subangulate, with a narrow, subangular median and basal keel. Sutures excavated. The area between the keels depressed or gently concave, the surface crossed with fine, curved threads. Surface of each whorl immediately below the suture faintly nodulose.

Dimensions.—Height, 3.5 mm.; greatest diameter, 4.5 mm.

Affinities.—This species appears to be nearest allied to the living *Liotia mayana*, Tate.[2] It essentially differs from that species, how-

1. Tate, Trans. Roy. Soc. S. Austr., vol. xxiii., 1899, p. 266, pl. viii., fig. 11.
2. Trans. Roy. Soc. S. Austr., vol. xxiii., 1899, p. 227, pl. vi., figs. 5a-c.

ever, in its more trochoid form, in the stronger thread-like surface ornament, and in the excavated sutures.

Observations.—A well preserved but aberrant or distorted variant of this species occurs in the Dennant Collection (Nat. Museum), from the Lower beds of Muddy Creek (Balcombian).

Distribution.—Bore 8, 180-199 feet.

Fam. TROCHIDAE.

Genus EUCHELUS, Philippi.

EUCHELUS BACCATUS, Menke sp. (Plate XXVI., Fig. 14).

Monodonta baccata, Menke, 1843, Moll. Nov. Holl., p. 14, No. 5.

Euchelus baccatus, Menke, sp., Tryon, 1889, Man. Conch., p. 435, pl. lxii. figs. 72, 73.

Observation.—The Mallee example appears at first sight to have a neater and more concise ornament than fresh shells of this living species. The difference, however, appears to be more apparent than real, and produced by the process of fossilisation. In the characters of the beaded spirals, the obliquely interstriated areas and the absence of a true umbilicus, it agrees with the somewhat variable species *E. baccatus.* The fossil specimen here occurs in a mixed Janjukian and Kalimnan fauna, but the shell is probably of the latter age.

Distribution.—Bore 5, 175-189 feet.

Genus CLANCULUS, Montfort.

CLANCULUS sp., aff. ALOYSII, T. Woods.

Clanculus aloysii, T. Woods, 1876, Proc. R. Soc. Tas., p. 155. *Trochus (Clanculus) aloysii*, T. Woods sp., Tryon, 1889, Man. Conch., vol. xi. p. 59, pl. xiv. figs. 20-23.

Observations.—A specimen in the neanic stage occurs in one of the bores, the ornament of which is clearly that of a *Clanculus.* In its subacute liration and interstriate areas, it most nearly resembles the above species. *C. aloysii* is a common living Australian species.

Distribution.—Bore 3, 201-220 feet.

Fam. UMBONIIDAE.

Genus TEINOSTOMA, H. and A. Adams.

TEINOSTOMA DEPRESSULA, sp. nov. (Pl. XXVII., Figs. 24*a*, *b*).

Description.—Shell depressed convex; on apical face sutures flush with surface. Periphery rounded. Umbilicus filled in with a callus, but the area is distinctly concave. Aperture subovate. Surface polished, and under a high power finely striated with growth-lines.

Dimensions.—Greatest diameter, 1.84 mm.; height, .75 mm.

Observations.—The above species occurs in three samples of strata in Bore No. 10, all of which contain a Kalimnan fauna, and therefore the horizon of the species is definitely known.

Distribution.—Bore 10, 186-190 feet; 195-225 feet; 225-250 feet.

TEINOSTOMA PULCHERRIMA, sp. nov. (Pl. XXVII., Figs. 25*a-c*).

Description.—Apical aspect naticoid, depressed; whorls rapidly widening, consisting of three coils. Lower side depressed, and concave in the umbilical area; umbilicus only partially filled with callus. Surface marked with fine, but definitely incised growth-lines, which under a high power are seen to be crossed by fine sulcate markings, giving the surface a highly ornate appearance. Aperture sub-quadrate.

Dimensions.—Greatest diameter, 4.75 mm. Height, 1.75 mm.

Observations.—The above species is an aberrant form of *Teinostoma*, and on account of the partially open umbilicus might eventually find a place in Cossmann's genus *Bonnetia*.[1]

A second specimen was found in the borings in the Mallee, but not figured. It belongs to the same specific type, but shows a slight variation in having the sutures of the whorls on the apical side more excavate and the whorls themselves less rapidly increasing in width. The surface ornament is identical, whilst the aperture is of the same general form, but more roundly ovate, owing to the narrower terminal whorl, and the umbilicus is slightly more open.

Affinities.—There appear to be no fossil or living representatives of this form of shell closely approaching it in all characters, perhaps the nearest being the living *Teinostoma orbitum*, Hedley.[2]

1. Annales Soc. Roy. Zool. et Malac. Belg., vol. xli., 1906, p. 207. (Genotype figured on pl. ix., fig. 16 ter-1).

2. Proc. Linn. Soc. N. S. Wales, vol. xxv., 1900, pt. i., p. 96, figs. B 15.

of Port Darwin and Torres Strait. The living species has a thinner lip and stronger spiral surface-markings.

Distribution.—Bore 3, 201-220 feet (var.). Bore 10, 225-230 feet (Holotype.)

Genus CYCLOSTREMA, Marryatt.

Cyclostrema homalon, Verco.

Cyclostrema homalon, Verco, 1907, Trans. R. Soc. S. Austr. vol. xxxi. p. 305, pl. xxix. figs 3, 4. Gatliff and Gabriel, 1913, Proc. Roy. Soc. Vict., vol. xxvi. (N.S.), pt. I., p. 75.

Observations.—This is a living species on the South Australian and Victorian coasts. It is distinguished from Petterd's earlier described *Cyclostrema harriettae*, which also occurs in the borings, by its wider umbilicus and coarser spiral markings.

Some examples of *Cyclostrema* in the Dennant collection (Nat. Museum) from Guerard's Hill (Janjukian), and from the Gippsland Lakes (Kalimnan), if not identical with the above species, are closely allied to it.

The present occurrence is from a Kalimnan horizon.

Distribution.—Bore 10, 195-225 feet.

Cyclostrema harriettae, Petterd.

Cyclostrema harriettae, Petterd, 1884, Journ. Conch., p. 141, No. 24. Tate and May, 1901, Proc. Linn. Soc. N.S. Wales, vol. xxvi. pt. 3, p. 396, pl. xxv. figs. 46-48.

Observations.—This species, like the preceding, is here recorded as a fossil for the first time, and it is interesting to note its occurrence as far down as the Kalimnan. Its undoubted relation to the form separated by Dr. Verco as *C. homalon* is also demonstrated in the fossil specimens, and the two forms occur on the same stratigraphical platform.

C. harriettae is a living species on the Victorian and Tasmanian coasts.

Distribution.—Bore 6, 114-150 feet.

Fam. EULIMIDAE.

Genus EULIMA, Risso.

Eulima pinguicula, sp. nov. (Pl. XXVII., Fig. 26).

Description.—Shell pyramidal, (?) subacute at apex; whorls seven, the earlier ones subdepressed, gradually becoming more convex, the last being rather swollen. Sutures well marked. Aperture long-ovate, with a thin callosity on the columellar margin. Surface polished.

Dimensions.—Length (circ.), 5.5 mm. Width (circ.), 2 mm.

Observations.—Four specimens of this rather distinct species were found at one horizon in one of the Bores. It has a larger aperture than *E. danae*, T. Woods,[1] whilst the whorls are more convex, and the apex is less acute.

The living species, *Eulima inflata*, Tate and May,[2] of Tasmania and Victoria, is a shorter shell with a more circular aperture; otherwise it bears some resemblance to the above species.

Distribution.—Bore 10, 225-230 feet.

Fam. PYRAMIDELLIDAE.

Genus PYRAMIDELLA, Lamarck.

Pyramidella jonesiana, Tate sp.

Odontostomia (*Syrnola*) *jonesiana*, Tate, 1898, Trans. R. Soc. S. Austr., vol. xxii. p. 70; p. 82 (fig.)

Pyramidella jonesiana, Tate sp. Pritchard and Gatliff, 1900, Proc. R. Soc. Vict., vol. XIII (N.S.), pt. I. p. 147.

Observations.—The above species was first described by Professor Tate from fossil specimens (Werrikooian) from the Tintinara Bore, S. Australia.

P. jonesiana is related to *P. tincta*, Angas sp.,[3] another recent Victorian species, but is distinguished from the latter by its greater breadth.

It is noteworthy that this is another living species occurring also in the Cainozoic strata of Victoria and S. Australia. It is found

1. Proc. Linn. Soc. N. S. Wales, vol. iv., 1880, p. 2, pl. i., fig. 1.
2. Trans. R. Soc. S. Austr., vol. xxiv., 1900, p. 95. Proc. Linn. Soc. N. S. Wales, vol. xxvi., 1901, pt. 3, p. 381, pl. xxv., fig. 58.
3. Proc. Zool. Soc. Lond., 1871, p. 15, pl. i., fig. 11.

both in the Werrikooian (Upper Pliocene) and the underlying Kalimnan (Lower Pliocene) in the Mallee Bores.

The distribution of the living examples is Flinders and Westernport, Victoria.

Distribution.—Bore 1, 215-244 feet. Bore 6, 114-150 feet. Bore 10, 160-186 feet; 186-190 feet; 195-225 feet; 225-230 feet. Bore 11, 197-199 feet.

Genus TURBONILLA, Risso.

TURBONILLA WEEAHENSIS,[1] sp. nov. (Pl. XXVIII., Figs. 27*a*, *b*).

Description.—Shell turreted, moderately elongate. Holotype with eight flattened whorls and a heterostrophe apex; whorls slightly concave below the sutures. Aperture subquadrate, lip thin. Surface of shell with about 24 shallow, sinuate sulci on each whorl. Sutures well marked. The shell-surface between the sulci finely striate, longitudinally.

Dimensions.—Height of holotype, 7.25 mm. Greatest width, 2.5 mm.

Distribution.—Bore 10, 225-230 feet; 310-320 feet.

Fam. CAPULIDAE.

Genus CALYPTRAEA, Lamarck.

CALYPTRAEA KALIMNAE, sp. nov. (Pl. XXVIII., Figs. 28*a-c*, 29).

Description.—Shell of thick substance, sub-circular in basal outline. Spire excentric; apex slightly exsert. Sutures well marked, whorls slightly to gently convex, marked by growth lines, corrugations and striae, except on the first two whorls, which are smooth. Base marked by sinuous growth-lines. Umbilical region with a callus and very small perforation.

Dimensions.—Major diameter of holotype (from Dennant coll.), 10 mm. Height, 6.5 mm. Diameter of a typical specimen from the Mallee Bore, 4 mm.

Observations.—The above species is represented by a large number of immature examples in the Mallee bores. They all occur on the Kalimnan horizon. Since they are undeveloped specimens it has been considered necessary to select as a holotype of the species a fine example from the Dennant collection (labelled *Calyptraea* sp.) from the Gippsland Lakes.

1. Name derived from Co. Weeah in which the bores are situated.

Affinities.—*C. kalimnae* is undoubtedly closely allied to *C. placuna*, Tate,[1] from the Aldinga Cliffs and the Adelaide Bore, S. Australia. It differs, however, from that species in its incrassate type of shell, more evenly convex whorls, thicker carinate edge and sub-circular rather than circular outline.

Distribution.—Bore 5, 155-159 feet. Bore 6, 114-150 feet. Bore 8, 165-180 feet; 204-210 feet. Bore 9, 254-256 feet; 256-263 feet; 263-273 feet; 315-325 feet. Bore 10, 186-190 feet; 254-296 feet.

Fam. NATICIDAE.

Genus NATICA, Lamarck.

NATICA SUBINFUNDIBULUM, var. CRASSA, Tate.
(Pl. XXVI., Figs. 15*a*, *b*).

Natica subinfundibulun, var. *crassa*, Tate, 1893, Trans. R. Soc. S. Austr., vol. xvii. pt. 327.

Observations.—Tate refers to this variety as "distinguished simply by its thick test and usually larger size, attaining to 20 mm. in length and width." The size of present specimen is considerably greater than that given by Prof. Tate, having a length of 50 mm. and a width of 52 mm. It was fortunately jammed in the convolutions of the shell auger, and so escaped comminution. This variety, *crassa*, has been found in both the lower and upper beds of Muddy Creek (Balcombian and Kalimnan), and at Beaumaris (Kalimnan). In the present case the associated fossils indicate a Kalimnan age for the horizon of this variety.

Distribution.—Bore 10, 220 feet.

Fam. RISSOIDAE.

Genus RISSOA, Fréminville.

RISSOA GATLIFFIANA, sp. nov. (Pl. XXVIII., Fig. 30).

Description.—Shell minute, conical and subelongate; moderately thick and polished. Whorls four; depressed convex, excepting the body whorl; the last two whorls ornamented with closely-set, fine, spiral incised lirae, about 24 on body whorl. Suture well marked. Apical whorl flattened. Aperture ovate, lip protracted behind, where its margin is dèhiscent from the body whorl; laminate internally.

Dimensions.—Length, 2.3 mm.; greatest width, 1.15 mm.

1. Trans. R. Soc. S. Austr., vol. xvii., pt. 2, 1893, p. 331, pl. vii., fig. 4.

Observations.—This very distinct little *Rissoa* does not seem to be matched or even approached by any other form, living or fossil, at any rate in Australian faunas. We take the opportunity of naming the species after our friend Mr. J. H. Gatliff, who has worked so assiduously amongst the gasteropod fauna of the Victorian coast.

Distribution.—Bore 10, 225-230 feet, four specimens).

Sub-genus ONOBA, H. and A. Adams.

RISSOA (ONOBA) BASSIANA, Hedley. (Pl. XXVIII., Fig. 31).

Onoba bassiana, Hedley, 1911, Zool. Results, F.I.S. "Endeavour," Part I., p. 108, pl. xix. fig. 25.

Observations.—This species was lately described by Mr. Hedley from off Devonport, Tasmania (depth unrecorded), and it is also known from Port Albert, Victoria (Gatliff and Gabriel). It is interesting to meet with this additional example of a species which, whilst occurring in the Kalimnan of the old Murray Gulf, still remains in evidence as a component of the living molluscan fauna of Bass Strait. The fossil example here figured has a length of 5 mm., whilst Hedley's type measures 4.5 mm.

Distribution.—Bore 6, 158-161 feet. Bore 8, 165-180 feet; 180-199 feet; 204-210 feet. Bore 9, 315-325 feet.

RISSOA (ONOBA) CHRYSALIDA, sp. nov. (Pl. XXVIII., Figs. 32, 33).

Description.—Shell pupiform, stoutly built, polished. Whorls four, depressed convex, with a spiral or helicoid apex of two and a half turns. Sutures shallow, excavated. Aperture circular, lip thick. Faint colour bands parallel with and near to the sutures are seen in some specimens. Under a high magnification surface marked with fine growth lines.

Dimensions.—Length, 3.1 mm.; greatest width, 1.5 mm.

Observations.—This neat little shell is a characteristic fossil of the Kalimnan series in Victoria. It is a rather variable form in regard to the height of the whorls, and an extreme variety from the Dennant coll. is here figured, in addition to the central type form. The same shell was named in MS. by Mr. J. Dennant as *R. chrysalida,* and in the Dennant collection (Nat. Museum) there are numerous examples collected from the upper beds of Muddy Creek.

Distribution.—Bore 8, 165-180 feet; 180-199 feet; 204-210 feet; 210-219 feet. Bore 9, 254-256 feet. Bore 10, 254-296 feet.

Fam. TURRITELLIDAE.

Genus TURRITELLA, Lamarck.

TURRITELLA CIRCUMLIGATA, Verco.

Turritella circumligata, Verco, 1910, Trans. R. Soc. S. Austr., vol. xxxiv. p. 123, pl. xxx. figs. 3, 4.

Observations.—The two individuals found in the bore have been compared with living specimens received from Dr. Verco, obtained off Beachport, S. Australia, at 110 fathoms. They are separable from the thickly corded varieties of *T. tristira*, Tate,[1] by having two heavy ligae, the anterior of which is generally separated into three by deeply incised spiral furrows, the central division being the thickest. The surface of the spiral cords is marked with fine oblique striae.

Distribution.—Bore 3, 226 feet.

TURRITELLA PAGODULA, Tate.

Turritella pagodula, Tate, 1893, Trans. R. Soc. S. Austr., vol. xvii. pt. 2, p. 336, pl. viii. fig. 10.

Observations.—This species has hitherto been recorded from three localities of the Kalimnan series, viz., Gippsland Lakes, Beaumaris and Horsham. It is absent from the Hamilton beds, but occurs in some abundance in the Mallee bores, thus pointing to the isolation of the former locality in Lower Pliocene times from the Great Murray Gulf area, which had direct connection with the Port Philip and Bairnsdale Kalimnan shore-line. The Mallee specimens are typical.

Distribution.—Bore 4, 163-170 feet. Bore 5, 155-159 feet; 163-175 feet; 175-189 feet. Bore 6, 114-150 feet. Bore 8, 165-180 feet; 180-199 feet; 204-210 feet; 225-226 feet. Bore 9, 254-256 feet; 315-325 feet.

Fam. CERITHIIDAE.

Genus CERITHIUM, Bruguière.

CERITHIUM TORRII, Tate.

Cerithium torrii, Tate, 1899, Trans. R. Soc. S. Austr., vol. xxiii. p. 109, pl. I. fig. 2.

Observations.—A partially pyritised specimen occurs in this series. In places the shell still remains intact, and shows the

1. Trans. Roy. Soc. S. Austr., vol. xvii., 1893, p. 338, pl. viii., fig. 8; pl. x., fig. 3.

"closely and minutely reticulate-lined" surface characteristic of this species. The general form of the shell is near *C. pritchardi*, Harris,[1] but the whorls are flattened and the costate ornament occupies the whole height of each turn.

C. torrii was first described by Prof. Tate from material obtained at the bottom of a deep well at Tareena on the Murray, in New South Wales, just across the Victorian border.

Distribution.—Bore 5, 162-168 feet.

Fam. CASSIDIDAE.

Genus CASSIS, Lamarck.

Cassis contusus, Tate.

Cassis contusus, Tate, 1899, Trans. R. Soc. S. Austr., vol. xxiii. p. 108, pl. I. figs. 1*a*, *b*.

Observations.—A fragment of this species was found in the Mallee bores. The contused markings arranged in three spiral rows round the body whorl are a characteristic feature in this species. It was originally described, like the preceding species, from a well-boring at Tareena, on the Murray, in New South Wales.

Distribution.—Bore 2, 198-200 feet.

Sub-genus SEMICASSIS (Klein), Mörch.

Cassis (Semicassis) subgranosa, Tate sp.

Semicassis subgranosa, Tate, 1889, Trans. R. Soc. S. Austr., vol. xi. p. 166, pl. vii. fig. 10.

Observations.—This rare species is distinguished from *C. (S.) semigranosa* by the stronger costate ornament and the spirally sulcated body whorl.

The only locality hitherto yielding this species is Edithburg, Yorke's Peninsula, S. Australia, where it occurs in the "hard raggy limestones."

Distribution.—Bore 6, 154-158 feet.

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1. Cat. Tert. Mollusca, Australasia (Brit. Mus.), 1897, p. 226, pl. vii., fig. 3.

Fam. BUCCINIDAE.

Genus NASSA, Martini.

NASSA SPIRALISCABRA, sp. nov. (Pl. XXVIII, Fig. 34).

Description.—Shell long—ovate, with a sharply pointed apex. Whorls below the apex four to five, depressed, and slightly concave in the posterior third; apex of three and a-half smooth whorls. Surface ornament consisting of moderately thin costae, becoming beaded towards the suture. Body whorl more inflated, and spirally scratched by fine grooves, which pass across the longitudinal ribs; the spiral grooves less conspicuous on the earlier whorls. Sutures deeply excavated; whorls tabulate. Outer lip with external marginal varix; internally with feeble denticulae. Columellar area with a moderately broad callosity, anteriorly denticulate.

Dimensions.—Height of holotype, 10.5 mm.; greatest width, 5.25 mm.

Affinities and Observations.—The nearest related form to the above species is *Nassa labecula*, Adams,[1] From that form it differs, however, in its longer or more turreted shell and a less extent of callus on the inner lip, and more numerous ribs.

N. spiraliscabra is associated with distinctive Kalimnan species in the samples present.

Distribution.—Bore 6, 114-150 feet. Bore 8, 199-204 feet.

Fam. VOLUTIDAE.

Genus MARGINELLA, Lamarck.

MARGINELLA HORDEACEA, Tate.

Marginella hordeacea, Tate, 1878, Trans. R. Soc. S. Austr., vol. I., p. 91.

Observations.—The Mallee specimens are not so broadly ovate as those from the type locality of Tate, namely, Aldinga, S. Australia. Examples of the shell in the Dennant coll. (Nat. Mus.) show, however, that the species varies in the same locality, but in different proportions. For instance, in the Kalimnan of Muddy Creek the majority of shells are broadly ovate, and a few ovate; from Aldinga, of two specimens in the collection named, one is narrowly ovate, the other broad; and from the Gippsland Lakes they are nearly all broad forms. The spire is not so exsert as in *M. praeformicula*,

1. Proc. Zool. Soc. Lond., 1851, p. 98. Reeve, Conch. Icon., vol. viii., 1855, pl. xxv., fig. 166.

next described, and the shell is smooth; otherwise it somewhat resembles that species in general contour and in the arrangement of the plaits.

Distribution.—Bore 10, 225-230 feet.

MARGINELLA PRAEFORMICULA, sp. nov. (Pl. XXVIII., Fig. 35).

Description.—Shell of medium size, volutiform, of solid build. Spire of medium length, conspicuously exserted. Whorls four, convex, and with about ten sharp plications on the shoulder of the body whorl. Sutures with a flattened, depressed area. Aperture long, sinuous and expanded anteriorly. On the dorsal aspect of the shell the lip margin is limbate, or thickened with a varix. Columellar plaits four, the anterior large and oblique, the two posterior small and transverse.

Dimensions.—Length, 8.5 mm.; greatest width, 5 mm.

Affinities.—The nearest form to the above species is the living Australian *Marginella formicula*, Lamarck.[1] In that shell, however, the plicae are more numerous and less acute; the whorls are more tabulate; the outer lip less expanded posteriorly; and the number of whorls five, against four in *M. praeformicula.* The fossil species foreshadows all the characters of the above-mentioned living form so closely that there can be little question of its being ancestrally related.

Distribution.—Bore 3, 201-220 feet; 226 feet. Bore 5, 155-159 feet; 175-189 feet. Bore 6, 114-150 feet; 158-161 feet. Bore 7, 142 feet 3 inches-155 feet. Bore 8, 165-180 feet; 180-199 feet; 199-204 feet. Bore 9, 315-325 feet.

Fam. TEREBRIDAE.

Genus TEREBRA, Lamarck.

TEREBRA PROFUNDA,[2] sp. nov. (Pl. XXVIII., Fig. 36).

Description.—Shell cerithioid, elongate, consisting of nine broad, convex whorls and a protoconch of two and a-half whorls. Longitudinal costae nine on each whorl, subacute and transversely scored by fine sulcose lines, eight on the penultimate whorl. Surface of whorls posteriorly depressed concave, anteriorly convex. Sutures deeply impressed. Aperture subquadrate.

Dimensions.—Length, 10.75 mm.; greatest with, 3.25 mm.

Distribution.—Bore 10, 225-230 feet.

1. Anim. sans Vert., vol. x.. 1822, p. 441. Reeve, Conch. Icon., vol. xv., 1864, pl. viii. figs. 28*a*, *b*.

2. That is, obtained by deep boring.

Fam. PLEUROTOMIDAE.

Genus PLEUROTOMA, Lamarck.

Sub-genus DRILLIA, Gray.

PLEUROTOMA (DRILLIA) DILECTOIDES, sp. nov. (Pl. XXVIII., Fig. 37).

Description.—Shell of medium size for the sub-genus, solid, fusiform with an acute apex. Shoulder sloping, base contracted, with a short canal. Whorls of the spire bicarinate; the body whorl with above five ridges, becoming weaker anteriorly. Apex acuminate, of three smooth whorls, seven whorls to the spire. Interspaces of carinae covered with closely-set thread-like and sigmoidal striae. Aperture with a moderately deep sinus, long, ovate and obliquely set.

Dimensions.—Holotype from Dennant coll. Length, 12 mm.; greatest width, 5 mm.

Observations.—The Mallee specimens being incomplete, it was necessary to select a fine example from an extensive series in the Dennant coll. (Nat. Mus.), from the Kalimnan of the Gippsland Lakes. These specimens were named in MS. by the late Mr. J. Dennant, F.G.S., as "*Drillia cochlearis.*" That species name, however, has been used in an allied genus, and we therefore rename it as *P.* (*D.*) *dilectoides*, in reference to its undoubted affinities to *Drillia dilecta*, Hedley.[1] The latter species, from moderately shallow water (24-75 fathoms) in the neighbourhood of Port Jackson, is separated, however, by its blunt apex, flatter sides, and longer and more vertical aperture.

Distribution.—Bore 6,114-150 feet; 158-161 feet. Bore 8, 180-199 feet.

EXPLANATION OF PLATES.

PLATE XXIV.

Fig. 1.—*Glycimeris maccoyi*, Johnston sp. Form *a*, with 32 riblets. Balcombian series. Grice's Creek, Port Phillip. Coll. W. Kershaw. Nat. size.

1. Mem. Austr. Mus., Mem. iv., pt. vi., 1903. (Sci. Results of Trawling Exped., "Thetis"), p. 387, fig. 100.

Fig. 2.—*G. maccoyi*, Johnston sp. Form *b* (=*Pectunculus laticostatus*, McCoy, non Q. and G.), with about 40 riblets. Janjukian series. From McCoy's type locality, Bird Rock Cliffs, Torquay. Coll. J. F. Bailey. Nat. size.

3.—*G. maccoyi*, Johnston sp. Interior of valve showing finely striated area. Janjukian series. Bird Rock, Torquay. Geol. Surv. Vict., coll. Nat. size.

4.—*G. maccoyi*, Johnston sp. Specimen with 29 riblets. Janjukian series. Table Cape, Tasmania. Nat. size.

5.—*G. maccoyi*, Johnston sp. Form *c*, with 30 riblets. Kalimnan series. Macdonald's, Muddy Creek, Coll. F. Chapman. Nat. size.

Plate XXV.

Fig. 6.—*Glycimeris laticostatus*, Quoy and Gaimard sp. Living. Coast of New Zealand. This species has about 40 riblets. Interior of valve to show the comparatively coarsely striate area. Nat. size.

7.—*Trigonia lamarcki*, Gray. Mallee Bore, No. 9, 315-325 feet. Nat. size.

8.—*T. lamarcki*, Gray. Living. Coast of New South Wales. For comparison with the above fossil. Nat. size.

9.—*T. lamarcki*, *Gray*. Costation of living specimen, magnified, × 7.

10.—*T. howitti*, McCoy. Costation magnified for comparison with the preceding figure. Cainozoic (Kalimnan series). Macdonald's, Muddy Creek. Dennant coll. × 7.

11.—*T. margaritacea*, Lamarck. Living example. Bass Strait. Nat. size.

Plate XXVI.

Fig 12.—*Trigonia margaritacea*, var. *acuticostata*, McCoy, Co-type of *T. acuticostata*, McCoy. Cainozoic (Kalimnan series). Beaumaris, Port Philip. Nat. size.

13*a*, *b*.—*T. margaritacea*, var. *acuticostata*, McCoy. Living example (2 valves). Bass Strait. Pres. by Capt. Stanley. Nat size.

14.—*Euchelus baccatus*, Menke sp. Oral aspect. Mallee Bore, No. 5, 175-189 feet. Nat. size.

15*a*, *b*.—*Natica subinfundibulum*, var. *crassa*, Tate. *a*, dorsal aspect; *b*, oral aspect; Mallee Bore, No. 10, 220 feet. Nat. size.

PLATE XXVII.

Fig. 16.—*Arcoperna scapha*, Verco. Mallee Bore, No. 3, 226 feet. × 4.

17*a-c*.—*Condylocardia tenuicostae*, sp. nov. *a*, exterior of left valve, × 13; *b*, cardinal area of left valve, × 26; *c*, cardinal area of right valve, × 26; *a* and *b*, Holotype. Mallee Bore, No. 10, 310-320 feet; *c*, Mallee Bore, No. 10, 225-230 feet.

18.—*Cardita calva*, Tate. An extreme variety with costation suppressed and concentrics dominant. Mallee Bore, No. 9, 254-256 feet, × 6.

19*a*, *b*.—*Donax kenyoniana*, sp. nov. Holotype, *a*, right valve × 2; *b*, portion of the same to show colour bands and radial striae; × 4. Mallee Bore, No. 10, 310-320 feet.

20.—*D. kenyoniana*, sp. nov. Paratype. Interior of left valve. Mallee Bore, No. 8, 160-165 feet. Nat. size.

21.—*D. kenyoniana*, sp. nov. Paratype. Ventral edge of valve interior. Mallee Bore, No. 10, 186-190 feet. × 8.

22.—*Liotia dennanti*, sp. nov. Holotype. Oral aspect. Mallee Bore, No. 8, 180-199 feet. × 4.

23.—*L. dennanti*, sp. nov. Paratype. Portion of shell more highly magnified to show intercostal, thread-like ornament. Cainozoic (Balcombian series). Lower beds, Muddy Creek. Ex. Dennant Coll. × 8.

24*a*, *b*.—*Teinostoma depressula*, sp. nov. Holotype. *a*, apical aspect; *b*, umbilical aspect. Mallee Bore, No. 10, 225-230 feet. × 8.

25*a-c*.—*Teinostoma pulcherrima*, sp. nov. Holotype. *a*, apical aspect, × 4; *b*, umbilical aspect, × 4; *c*, surface ornament, × 12. Mallee Bore, No. 10, 225-230 feet.

26.—*Eulima pinguicula*, sp. nov. Holotype. Mallee Bore, No. 10, 225-230 feet. × 8.

PLATE XXVIII

Fig. 27*a*, *b*.—*Turbonilla weeahensis*, sp. nov. Holotype, *a*, oral aspect, × 4; *b*, protoconch, × 26. Mallee Bore, No. 10, 225-230 feet.

Fig. 28*a-c*.—*Calyptraea kalimnae*, sp. nov. Holotype. *a*, apical aspect; *b*, lateral aspect; *c*, umbilical aspect. Cainozoic (Kalimnan series) Gippsland Lakes (ex Dennant Coll.) × 2.

29.—*C. kalimnae*, sp. nov. Paratype. One of the typically small forms from the Mallee Bores (No. 8, 165-180 feet). × 2.

30.—*Rissoa gatliffiana*, sp. nov Holotype. Mallee Bore, No. No. 10, 225-230 feet. × 20.

31.—*Rissoa (Onoba) bassiana*, Hedley. Mallee Bore, No 8, 180-199 feet. × 8.

32.—*Rissoa (Onoba) chrysalida*, sp. nov. Holotype. Typical form. Mallee Bore, No. 9, 254-256 feet. × 8.

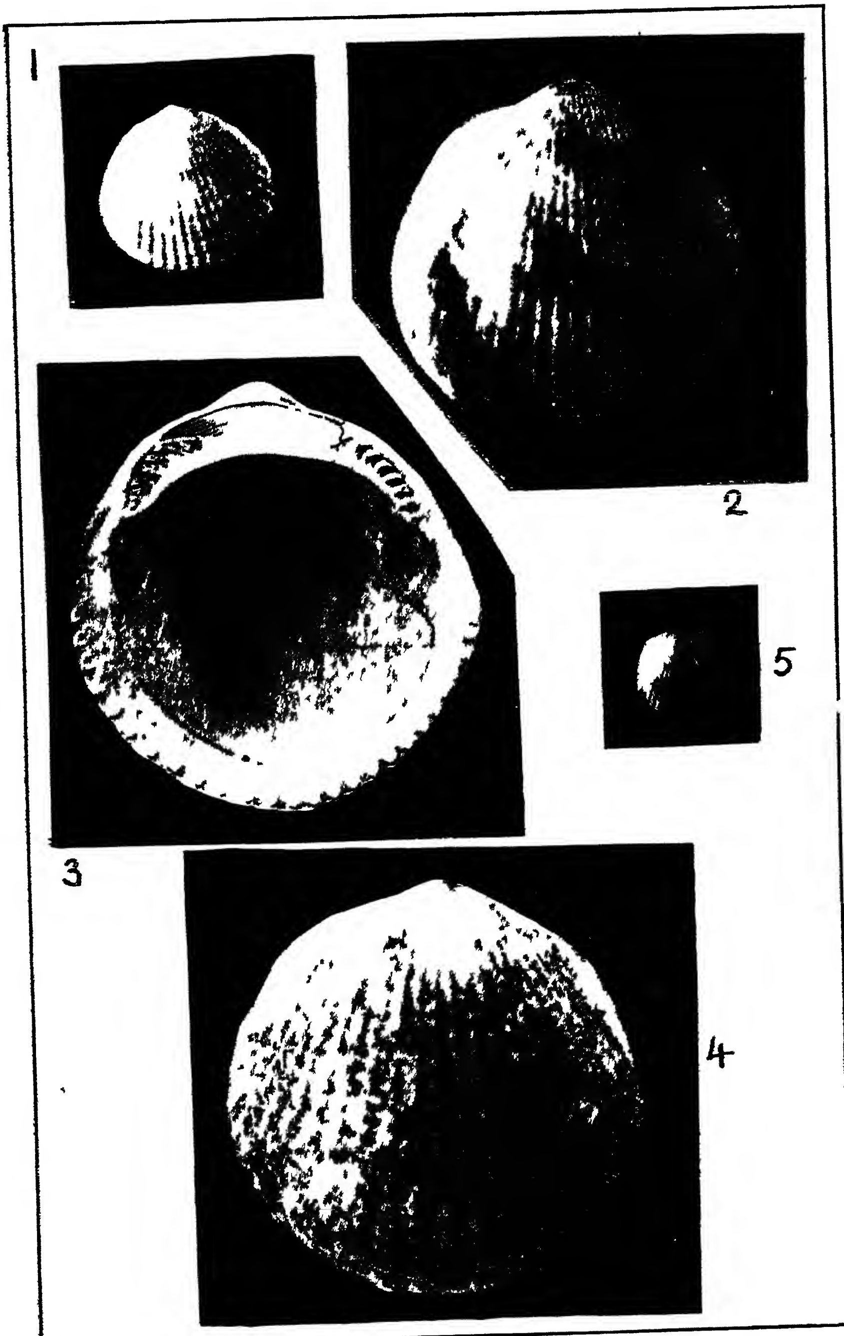
33.—*Rissoa (O.) chrysalida*, sp. nov. Paratype. Extreme, elongate form Cainozioc (Kalimnan series). Upper beds, Muddy Creek. Ex. Dennant Coll. × 8.

34.—*Nassa spiraliscabra*, sp. nov Holotype. Mallee Bore, No. 8, 199-204 feet. × 4.

35.—*Marginella praeformicula*, sp. nov. Holotype. Mallee Bore, No. 8, 180-199 feet. × 4.

36.—*Terebra profunda*, sp. nov. Holotype. Mallee Bore, No. 10, 225-230 feet. × 4.

37.—*Pleurotoma (Drillia) dilectoides*, sp. nov. Holotype. Cainozoic (Kalimnan series). Gippsland Lakes. Ex. Dennant coll. × 4.



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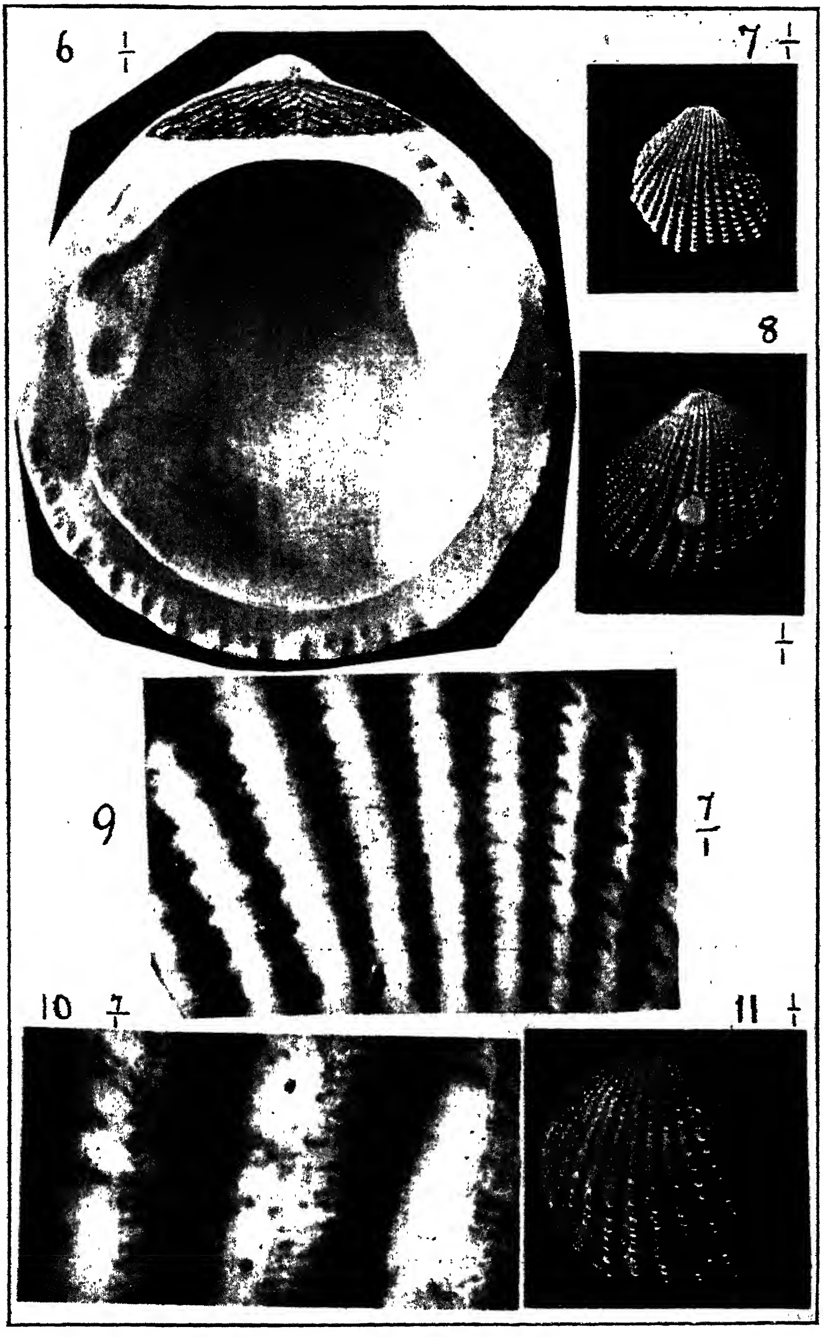

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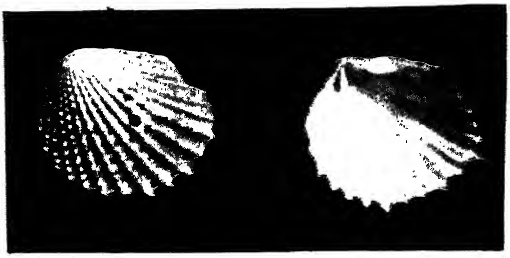

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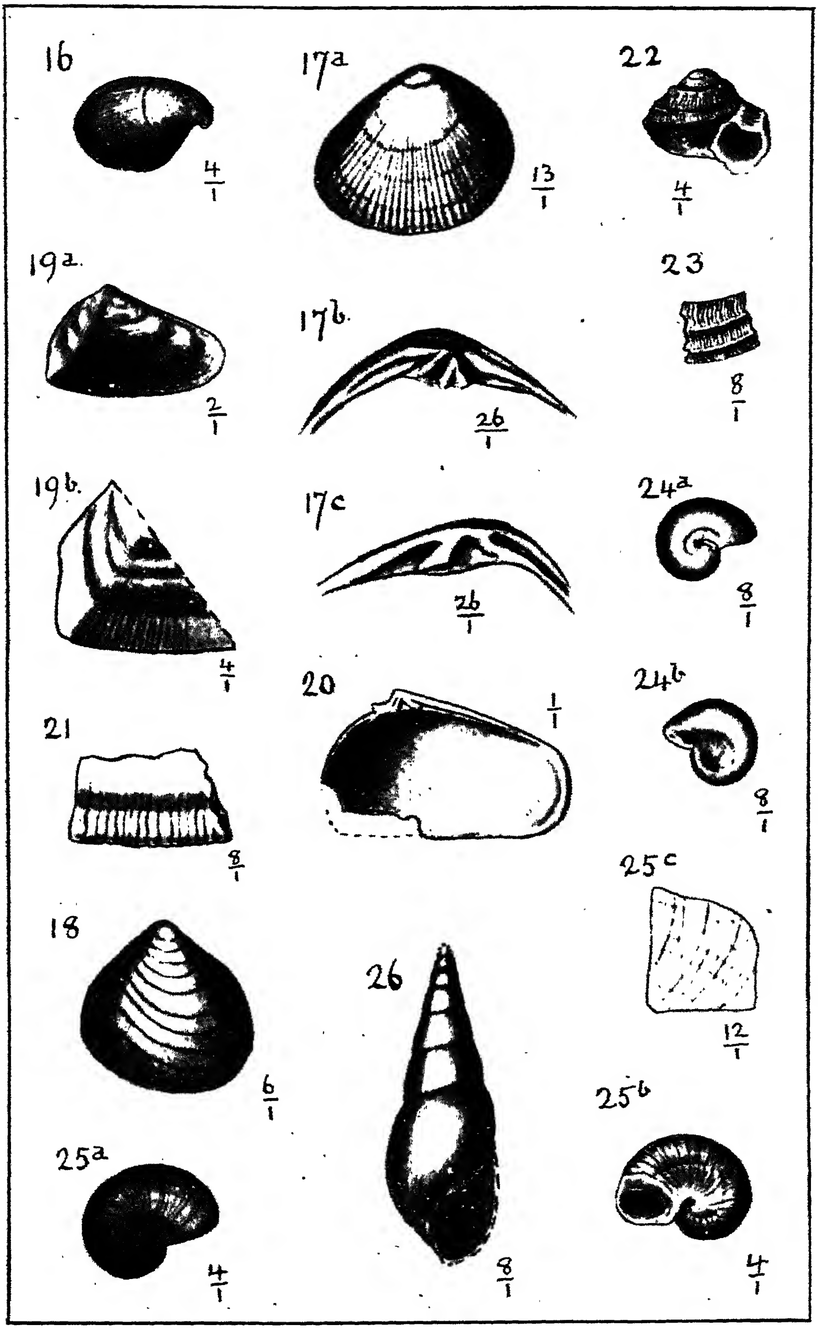
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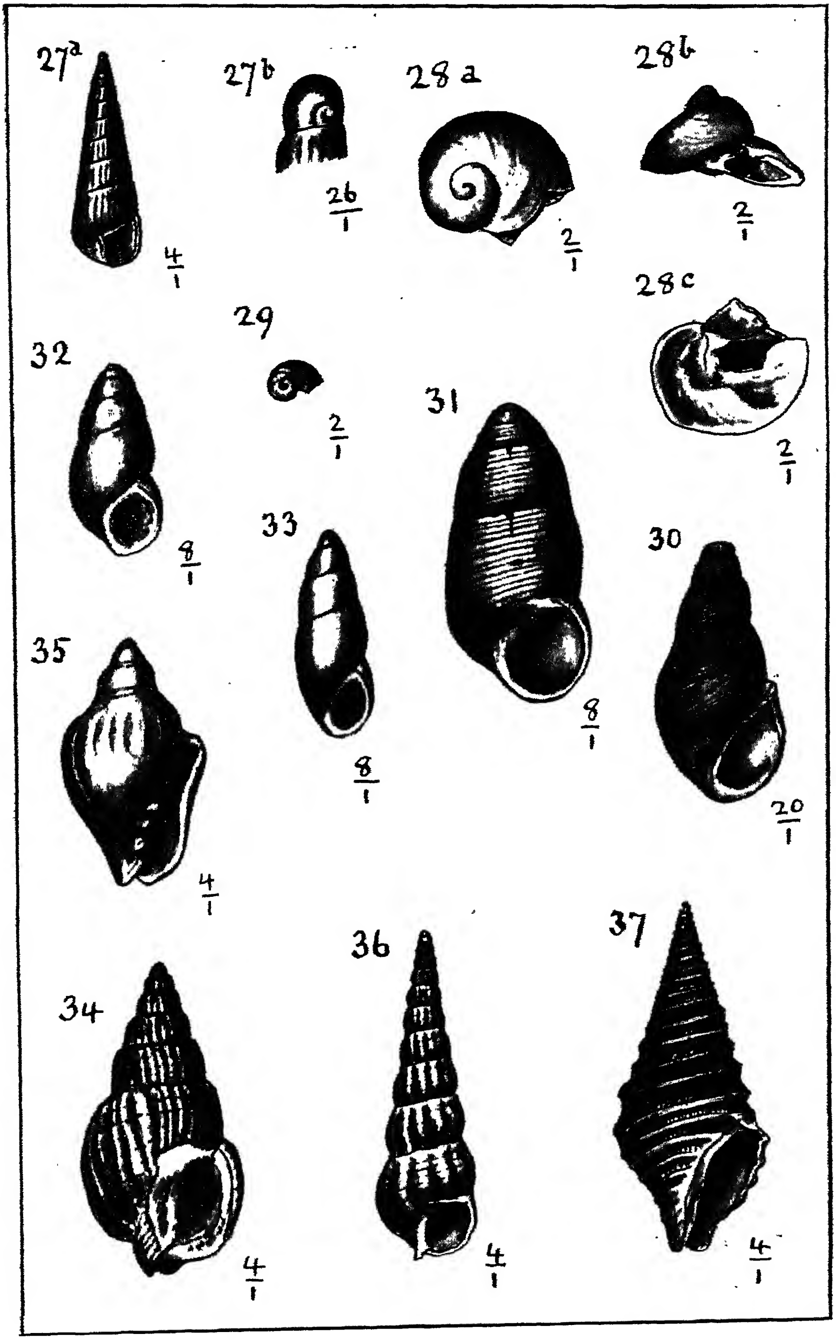
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[Proc Roy Soc Victoria, 26 (N.S.), Pt. II, 1914.]

Art. XXII.—*On the Geology and Petrology of the District between Lilydale and Mount Dandenong.*

By MORRIS MORRIS, M.Sc.

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(With Plates XXIX., XXX. and XXXI.)

[Read 13th November, 1913.]

Contents.

I.—Introduction.

The area to be described lies about 23 miles east of Melbourne. It is a rectangular block of some 36 square miles, with its southern base line passing east and west across the Trig Station on Mt. Dande-

nong, and its northern boundary running in a similar direction about one mile north of Lilydale. Laterally, it reaches from about Mooroolbark in the west to near Wandin in the east.

From Mt. Dandenong one looks eastward across the Woori-Yallock basin to the closely related mountains of Healesville and Warburton, northwards to the Dividing Range, beyond the alluvial flats of the Yarra, and westwards and southwards across a dissected plain, sloping towards the coast line.

It was found necessary to extend the mapping in various directions beyond the limits above defined, but such extensions are omitted, and will only be referred to when necessary to illustrate features that already appear in the circumscribed area.

II.—Previous Work.

In 1856 Sir A. R. C. Selwyn (1) made a brief description of Cave Hill, near Lilydale, where he found "the entrance to a cave 120 feet deep," which eventually became the site of Mr. Mitchell's limestone quarry.

In 1892-3 Rev. A. W. Cresswell, M.A. (3, 4), wrote two papers, both of which deal almost solely with the fossiliferous contents of the Cave Hill limestones.

It was not till six years later that any work was commenced on the stratigraphy of the district. In 1899 the late V. R. Stirling (8) published a brief description, and made a map, of Cave Hill and of a narrow strip of the district contiguous with it eastward as far as Lilydale, and westward across the railway line, where it embraces a small residual plateau capped with basalt. He failed, however, to recognise the important series of igneous rocks which flank Cave Hill on the east, and which, together with those of an earlier series, form the surface rock of Lilydale. These he called metamorphosed Silurian strata, being betrayed by a most deceptive resemblance which they bear to an indurated shale.

These two igneous series possibly belong to the opening movements of a great cycle of igneous activity, which culminated in the piling up of the Dandenong Rages. The remains of this system, which occupy the greater part of the area represented on the map, form the most conspicuous feature of the district, and will be the chief subject of this paper.

During 1910 I mapped and described the area contained in a triangle, whose apices are Mooroolbark, Lilydale and Evelyn. The present map and paper are an extension of these earlier unpublished observations.

Stratigraphical Classification.—The rocks of the district fall into four groups :—

1. A sedimentary series of the Upper Silurian epoch.
2. An igneous series of the Later Palaeozoic (?) period.
3. An igneous series of the Early Tertiary (?) period.
4. An alluvial series, Recent.

III.—The Upper Silurian Sediments.

Prof. Gregory (10) subdivided the Silurian of Victoria into a Lower or Melbournian Series, and an Upper or Yeringian Series. The Lilydale Silurians belong to, and form the type deposits of, the Upper Silurian, which were called Yeringian, after the parish where Lilydale is situated.

Between Melbourne and Warburton, the Silurians are apparently folded into two great synclines. In one of these, called by Prof. Gregory, "the Lilydale Synclinal," the Upper Silurians of the area under review have been preserved. This great syncline extends from the Warrandyte anticline on the west, through Lilydale and Yering, to the Woori Yallock basin on the east.

Lithological Characters.—The Yeringians are marine deposits, whose character varies with increasing distance from the old Silurian shore line. They vary between the conglomerates of Cave Hill, the sandstones and quartzites of Gruyere, the limestones of Mr. Mitchell's quarry, and the mudstones and shales of Mooroolbark and other places.

The Limestones.—There are two outcrops of limestone at Cave Hill, the one an occurrence about 80 yards square in Mr. Mitchell's quarry, the other a small outcrop about 4 feet square in the railway cutting, about 300 yards south of the quarry. The well-formed strata of the quarry dip east (8) at about 50 deg., and strike a few degrees east of north. Their eastern limit is determined by a thick bed of quartzite, which overlies them conformably. Their western limit is concealed under an overburden of basalt. (Plate XXX., Fig. 1.)

This limestone formation has been incompletely described by Sir A. R. C. Selwyn (1), R. A. F. Murray (7), A. W. Cresswell (2, 3, 4), and V. R. Stirling (8). Its abundant fossiliferous contents have been investigated by Sir F. McCoy, R. Ethridge, jun.; G. B. Pritchard, F. Chapman, and A. W. Cresswell.

Sir F. McCoy referred them to the Upper Silurian on palæontological evidence (7).

Similar limestone formations occur in the Upper Silurian at Waratah Bay, Tyers River, Buchan River, Thomson River (between Walhalla and Toongabbie), Loyola, and Delatite River near Mansfield.

According to Murray (7) all these are lithologically similar, being in each case crystalline rocks, and full of crinoid stems, replaced by $CaCO_3$. "The limestones are found in some cases to be undoubted lenticular intercalations."

Macroscopically examined, the Cave Hill limestone is a dark bluish gray, compact, crystalline, and medium grained rock. Fresh specimens do not readily exhibit their organic remains, but in weathered specimens, Hydrozoa, represented mainly by Favosites grandipora and Heliolites, and Brachiopoda, represented especially by Atrypa reticularis, occur in some cases perhaps as abundantly as Crinoidea.

Microscopic Examination.—The thin slices examined are crowded with fossil remains of all sizes, most of which appear to belong to the Hydrozoa. Their outlines are broad and dark, probably owing to impurities, but the interior is generally occupied by calcite. The whole is cemented together by interstitial calcite. A grain of quartz appears occasionally. Dolomite is rather common. It occurs in small rusty-coloured patches, and is identified by staining.

The signs of thermal metamorphism are entirely absent. The rock owes its crystalline structure to metasomatism chiefly, and possibly in some degree to stresses set up during the folding of the beds.

The Cave Hill Quartzites and Conglomerates.—This bed, which is not less than 70 feet thick, overlies the limestones of Mr. Mitchell's quarry conformably on the east, and forms their upper limit. Owing to its superior resistance to the forces of erosion, it is a prominent surface feature, forming the eastern flank of Cave Hill, and a neighbouring eminence, immediately south of Cave Hill.

At Cave Hill, the bed is a quartzite. Going south, it gradually develops into a loosely consolidated conglomerate, consisting of quartz pebbles set in a matrix of granular quartz. The pebbles are easily separated from the matrix.

Under the microscope, the quartzite is seen to consist of rounded grains of quartz chiefly, and a little felspar, most of which show nodulose extinction. The large interstices are often occupied by a fine matrix, some of which appears to have been produced in situ by the mylonitization of the grains. Much of the matrix seems to be a silicious cement, which is frequently ferruginous. The

mosaic structure of the thermal metamorphism is entirely absent. It is therefore evident that consolidation here, as in the limestone has been due chiefly to metasomatism, and possibly also in some degree to dynamic metamorphism during the folding of the beds. This result is interesting inasmuch as thermal metamorphism is the only process which Murray (7) and Stirling (8) suggested to account for their alteration. The only instance of thermal metamorphism of the Silurian, that I have seen in the district, occurs along the eastern shoulder of the Dandenong Range, where the sedimentaries have been converted into a hornfels.

South of Cave Hill the quartzites increase their dimensions gradually, spreading westwards, and giving place as they do so to a fine-grained sandstone. (See Fig. 6, Plate XXX.)

The limestone boulder in the railway cutting is flanked immediately on the east by these easterly dipping sandstones. Assuming that it is *in situ*, this boulder appears to form part of the thin end of a lenticular limestone formation, related to the Cave Hill strata as per Fig. 6. In this case, assuming the absence of faulting, the western limit of the Cave Hill formation lies as far to the west of the quarry as the railway line, and possibly beyond it.

The colonies of marine organisms, which formed the limestones, perished through the accumulation of sands, initiated probably by a movement of uplift. But the same sands which killed them have preserved their remains. Defended behind this quartzite rampart, and sheltered by a roof of basalt, the limestones have escaped destruction.

The prevalence of other quartzite and sandstone ridges to the north-east, in Gruyere, where they rise abruptly above the flats of the Yarra, together with the occasional presence of conglomerate, probably indicates the inception and progress of those movements of elevation, which caused the last retreat of the Silurian sea.

The disposition of the Gruyere ridges appears to be causally related to the strike and folding of the beds. (See Fig 5, Plate XXX.) They occur in two pairs, and each pair may be arranged along a straight line, parallel to the strike of the beds, and therefore to each other. Both lines strike 16 degrees east of north. (This easterly divergence is matched between Lilydale and Coldstream by a strike of 47 degrees to 53 degrees east of north, thus indicating a strong lateral easterly thrust in the Silurians north of Lilydale. Just east of Evelyn the strike diverges 38 degrees east of north.) The eastern pair both have a crescentic shape, with the crescent opening northwards. Of the western pair the northern one is also

in the form of a crescent, but it opens to the south. These phenomena may be explained on the hypothesis, that the eastern pair lie along an anticlinal axis, and the western pair along a synclinal axis, the fold in both cases pitching south.

Further, it is owing mainly to these resistant ridges that the Yarra has had to take such a long bend to the north after leaving the course set for it in the Warburton Gorge.

IV.—Late Palaeozoic Igneous System.

The great revival of igneous activity which occurred at many centres of Victoria in the late Palaeozoic, and produced, among other formations, the Snowy River Porphyries, the Strathbogies, and Mt. Macedon, developed in the district under review, into a cycle of three phases—a volcanic phase, including probably five series (of which the last three formed the Dandenong Ranges), a plutonic phase, and a hypabyssal phase.

Distribution.—The whole system has the form of a rough triangle, with its broken apex between Lilydale and Wandin. From this place, it extends south for twenty miles to the Gippsland railway line, near to which its broad base of about 15 miles is spread out between Dandenong and Pakenham. A line connecting Emerald with a point two miles south of Ferntree Gully divides this triangle into two parts, and, roughly speaking, the southern part contains the plutonic outcrops, and the northern part the volcanic rocks of the system.

This map and paper is chiefly occupied with the northern extremity of the volcanic series, and as this area, though small, contains all the series of the system, it therefore supplies material for the description of the whole cycle.

Relation to the Silurians.—The part of the system shown on the map is girdled on three sides by the Silurians, of which those on the west dip east, and those on the east dip west. The upturned edges of the Silurians dipping at a high angle may be seen almost in contact with the overlying igneous rocks at a quarry about $1\frac{1}{4}$ miles from Lilydale, along the railway line to Coldstream, and also at a small quarry about 200 yards north-east of Cave Hill. The igneous rocks therefore occupy a denuded syncline.

A.—The Volcanic Phase.

The volcanic rocks are represented by five series. Using Hatch's classification, but with reasonable elasticity, these series are as follows, naming them in the order of extrusion:—

a The Lower Toscanite series.
b The Upper Toscanite series.
c The Lower Dacite series (passing up into a fragmental series).
d The Middle Dacite series.
e The Upper or Hypersthene Dacite series.

For the sake of economy in space, when referring to these series, the above letters—*a*, *b*, *c*, *d*, and *e* are frequently used instead of giving the whole name.

a. The Lower Toscanite Series.

This is a complex series of lavas alternating with laminated formations, which ought probably to be regarded as a banded effusive rock.

Field relations. The series forms a rough arc reaching from Lilydale to within a mile of Wandin, bounded on its north and convex side by the alluvium and Silurians of the Yarra basin, and embracing on its concave side the next series (*b*) in the system. It is best developed on the west limb, where it forms the surface rock of the greater part of Lilydale, and also the prominent ridges just outside of the town on the north-east. It also occurs in small patches along the western edge of the system, even as far south as Montrose. There are two small patches of it east of Mooroolbark, one an inlier in the next series (*b*); and the other an outlier on the Silurians. It, therefore, had a wide distribution. Owing, probably, to denudation, it becomes less conspicuous going east from Lilydale, and occurs there only in discontinuous areas.

Stratigraphical Relationship.—(i.) Its wide distribution, and its invariable association with series *b*, show that these two adjacent series were co-extensive over a large area. (ii.) The chemical evidence show that *a* and *b* are inseparable. The one must, therefore, lie immediately, either above or below the other. (iii.) *a* is in many cases immediately underlain by the Silurians, and *b* is visibly in one place, and over a large area may be proved to be, overlain immediately by the series *c*. Therefore, since *a* cannot lie above *b*, it must be below it. This conclusion is further supported by the arrangement of vesicles in series *a*, in the railway cutting behind Lilydale, so as if continued to dip beneath the adjacent series, *b*. This conclusion is corroborated also by the apparent superposition of a high conical hill of series *b* on a low platform of series *a*, which flanks the former on the north and west.

Taking this evidence together, it seems safe to conclude that *a* is older than *b*.

Petrological Characters.—In the field, the members of this series appear so heterogeneous as to seem capable of further subdivision. But the microscopic evidence shows that they belong to one family. They agree in bearing phenocrysts of felspar, and a ground mass full of orthoclase, but with relatively little quartz. They differ in the structure of the ground mass, and in the nature and amount of ferro-magnesian minerals present.

Three types have been selected for description, (1) from the base of the series, (2) from the middle (3) from the top.

1. The Basal Member.—Specimen from quarry, allot. 24, north end. A hard, brittle, bluish-gray streaky rock, fine grained, with occasional phenocrysts of felspar.

Under the miscroscope, it is found that idiomorphic phenocrysts of plagioclase (probably oligoclase) are sparingly developed, and arranged parallel to the flow structures of the ground mass, which consists chiefly of felspar microlites, set in a sparse cryptocrystalline matrix. These microlites are of two kinds—(a) very minute laths of plagioclase (probably oligoclase), (b) larger and rhombic or square-shaped crystals of orthoclase. Orthoclase is greatly in excess of plagioclase in the ground mass, and apparently of the phenocrysts also. This is due to the high percentage of alkalis present (viz., 6.98 per cent.). Of CaO there is 1.95 per cent., most of which has combined with CO_2 without being removed, This is clear from the presence of 1.80 per cent. of CaO in the next series (*b*), which is nearly identical in chemical composition, and contains no CO_2. Iron oxide in the rectangular grains occur sparingly. Sericitic material and some secondary quartz leached from the matrix, occupy original vesicles or planes of weakness, and give the rock a streaky appearance. The specific gravity of this rock is 2.489. The chemical analysis is given later.

Its *industrial value* as metal for roads and ballasts is due to its hardness, to its brittleness rendering it easy of preparation, and to the absence of unstable minerals. It is extensively quarried for this purpose.

2. The Middle Member.—Specimen from railway cutting behind Lilydale. Like the basal member, except that it is not brittle, but, on the contrary, exceedingly tough, and also much more vesicular and streaky.

Phenocrysts of plagioclase, orthoclase (subordinate), and biotite in large flakes, are present, the latter being much decomposed, and the alteration products fill the original steam pores. One small phenocryst was found with the colour, pleochroism, cleavage, extinc-

tion, and polarisation characters of hypersthene. Iron oxide. apatite. and zircons occur as accessories. The ground mass is like that of the basal member. except that the orthoclase is not idiomorphic, but allotriomorphic. It envelopes the laths of plagioclase, and occupies the interstitial spaces so continuously that there is but little glassy base present. As the orthoclase has crystallised from various centres. it produces an extinction effect resembling strain shadows. Pronounced fluxional arrangement of laths and phenocrysts occurs. Granular chlorite and biotite are present, and also a little quartz.

The spec. grav. is 2.62 (for least altered specimens).

It forms the surface rock of the chief part of Lilydale, and also constitutes a big part of the hills. which overlook the town on the north-east.

3. Upper Member.—Specimen from Allot. 24, south end. A gray slate-coloured rock, fine grained, hard and tough, showing felspar phenocrysts with fluxional arrangement. Idiomorphic phenocrysts of plagioclase (probably labradorite) are common; apatite, zircon, and iron oxide rather frequent. The ground mass is like that of the middle member. and consists of microlites (probably oligoclase), surrounded by optically continuous patches of orthoclase. Elongated streaky areas of sericitic material abundant. and this, together with secondary quartz, occupies what seem to be original vesicles, or planes of weakness.

Spec. grav. 2.65.

Chemical and Mineralogical Characteristics.—The three members of the series agree in the relatively small amount of primary quartz present, considering the high SiO_2 contents (68 per cent.), and also in the prevalence of orthoclase in the ground mass. accounting for the high alkali contents (6.98 per cent.). They differ chiefly in the structure of the ground mass. In the basal member, the orthoclase formed regular-shaped crystals, and these set in a cryptocrystalline base, give the rock its brittle character. In the other members, the orthoclase crystallised more extensively, the patches from various centres moulding themselves on one another, and occupying the interstitial spaces so fully that but little base remains. These rocks are therefore very tough.

The abundance of orthoclase, and the subordinate quantity of quartz, in the ground mass of this series, has been effected by the assistance of mineralisers, especially water, of whose plentiful supply the vesicles bear evidence. This is further discussed below.

The high percentage of silica (68 per cent.), and of alkalis (6.98 per cent.), constitute this rock a toscanite, according to Hatch's classification.

The Geological Map.—This series is coloured Silurian on Selwyn's sketch map, and on the geological map of Victoria, having been regarded as altered sediments by Murray (7) and Stirling (8). The latter coloured this and the succeeding series (*b*) Silurian in his map of Lilydale, and shows in his section a hypothetical trappean mass under the township to account for their alteration.

b. The Upper Toscanite Series.

The visible distribution of this series resembles a shepherd's crook, the crook bending east at Lilydale, and enclosing the succeeding series of the system. From Lilydale, where it forms part of the surface rock, it runs south for seven miles, forming a narrow strip between the Silurians and the Lower Dacite series (*c*).

Petrological Character.—The whole series is characteristically homogeneous. The only variations are due to the alteration of effusive and explosive phases. The explosive types, varying from lapilli to agglomerate, are generally preserved in the form of hills, and some of these are probably close to, if not on the sites of, the volcanic vents. They are well developed opposite the Salvation Army farm, near Bayswater, and near Montrose. In the extreme northern part of its distribution, these fragmental types occur almost continuously over a large area, and they appear to become increasingly coarse towards a pair of high conical hills as centre, where the agglomerate contains fragments as big as a man's head. I, therefore, regard these two hills as denuded necks of Devonian toscanite volcanoes, and have marked them as such on the map.

The following is a description of the normal effusive rock when fresh :—

Macroscopic.—A blue-black, non-vesicular, compact, exceedingly fine-grained, brittle rock, intricately traversed by joint planes, and showing rather sparingly lustrous phenocrysts of felspar.

Microscopic.—Phenocrysts consist of plagioclase, some of which is determined to be oligoclase and andesine, idiomorplic, but sometimes corroded; glassy sanidine subordinate; biotite occasionally in small flakes; apatite, zircon, rutile, and rectangular crystals of iron oxide. The ground mass is microcrystalline. It contains a

little quartz and a good deal of felspar microlites, giving extinction angles from 0 deg. for the majority, up to 30 deg. for the rest. (Some of the former may be orthoclase.) Flow-structure is slightly indicated by the general parallel arrrangements of microlites and phenocrysts. Granular green slightly altered biotite is abundant.

Spec. grav. 2.66.

Owing probably to the easy passage offered to water along its intricate network of joint planes, the whole series has been subjected to such extensive alteration that it resembles more a whitish baked shale than an igneous rock. Previous writers (R. A. F. Murray (7) and V. R. Stirling (8)) have regarded it as metamorphosed Silurian. In this extremely altered condition, the felspar phenocrysts have disappeared, leaving rectangular cavities. The ground mass is felsitic, but shows much granular secondary quartz, veined by strings of the same mineral. In the freshest specimens the specific gravity is 2.66; in the altered type, it is 2.37, a loss of nearly 11 per cent.

The altered type of this series provides the chief road metal of the district, a use for which it is well adapted. Being rather brittle, it is easily prepared, and, while providing binding material, its condition as an ultimate decomposition product tends to prohibit the formation of dust and mud.

Chemical and Mineralogical Composition.—The chemical analysis of a member of this series is given later, and is practically identical with that of the preceding series (*a*). Silica (69.9 per cent.) and alkalis (6.9 per cent.) are both high, constituting the rock a toscanite like its predecessor. But, unlike its predecessor, the ground mass is abundant. It is glassy or microcrystalline, and it contains but little orthoclase.

Comparison of the toscanites (a and b).—The first two series, then, are toscanites. In each case quartz never appear in phenocrysts, and only to a comparatively small extent in the ground mass. But although their chemical composition is practically the same, there is a fundamental mineralogical difference between them, which prevents their being called facies of the same series. This difference, which as a rule appears so plainly on comparing the hand specimens, inheres in the ground mass. In the first series (*a*), the ground mass is often practically holocrystalline, owing to the abundance of orthoclase; in the second series (*b*), it is often almost non-crystalline, and orthoclase seems sparse or absent, while minute flakes of biotite are frequent. There can be no doubt that this difference was due to the fact that mineralisers, chiefly

water, were abundant in the first series (*a*), and almost absent from series *b*. Steam vesicles are often prevalent in the first series; they are entirely absent from the second.

Unlike most of the plagioclase felspars, orthoclase, and also quartz, cannot be produced artificially from simple fusion, except with the aid of water or other mineralisers. The water functions chemically as a catalyser, and physically as a flux, reducing the viscosity of the magma, and lowering the freezing points of its constituent minerals. It is well known that a simple fusion of the constituents of orthoclase becomes extremely viscous in the neighbourhood of its melting point. Harker (19) remarks, "It is easy to believe that the presence of a small amount of water may so reduce such viscosity as to enable the alkali felspar to crystallise freely."

We may, therefore, conclude that the presence of water in the first magma (*a*), enabled orthoclase to crystallise freely, while its absence from the second magma (*b*) restricted the process. Since the mineralisers must be regarded as an integral part of the rock magma, the reason for separating the first two series is obvious.

Evidence of Foliation.—In the quarry of Allot. 22c on the west limb of the system, series *b* acquires a very sight banded character, which is only discernible on a polished surface. This feature, in an accentuated form, is quite common in the lower series (*a*).

Specimens of series *a* from Allot. 23[a] show two sets of banding intersecting at a very small angle. In thin sections, the bands are seen to be occupied by the ordinary ground mass, and by abundant grains of a sericitic mineral, which is clearly secondary. The phenocrysts, and the few microlites which occur, are arranged with their long axes approximately parallel to the banding. The phenocrysts show scarcely any sign of strain shadows; therefore the banding was not produced by earth movements after consolidation. It must be explained, then, either as the bedding planes of a tuff or as foliation due to movement during consolidation. The parallel arrangement of the microlites and phenocrysts with reference to the banding, and the presence of *two* sets of bands, offer support to the latter hypothesis, and point to the possibility of these rocks having been involved to some extent in the last stage of the folding movements. This conclusion serves to corroborate the petrographic evidence in favour of the Lower Devonian age of the rocks of this system.

c. The Lower Dactite Series:—

This series is associated with its successor, "The Middle Dacite Series," (*d*), by strong affinities, which place the pair in sharp con trast with the first series, (*a* and *b*), which are also closely affiliated.

This series is characterised by abundant phenocrysts of quartz, and some of felspar and biotite, all set in a glassy to crypocrystalline ground mass. The series consists chiefly of lavas, charged with fragments of this and other igneous material, and of hornfels. In the weathered sections, exposed along the railway line between Lilydale and Evelyn, this included material is well exhibited. The fragments vary from the smallest size to that of a man's head. All this points to an alternation of explosive and effusive phases, resulting in the incorporation by the lava flows of showers of fragments.

Towards the close of the series the effusive phases disappeared, and it finished with a facies that is entirely fragmental. These rocks are best developed between Montrose and Evelyn on four lofty ridges, which run out from the main Dandenong Range northwards towards Olinda Creek. They vary from a coarse agglomerate to dun-coloured lapilli, containing no visible minerals. The latter occur always higher up than the former, and were probably the last phase of the series. For convenience, these fragmentals are referred to as "The Dandenong Agglomerates." (Plate XXX., Fig. 2.)

Close to the place where the Evelyn fault crosses Olinda Creek, the upper part of this fragmental series has been faulted down to stream level, and there the agglomerate is very coarse. One fragment measured fully 12 in. in diam., and it and others were more rounded than angular. There is little doubt that this place marks a centre of eruption. This is rendered still more likely by the proximity of the hornfels, fragments of which are so numerous in the effusive facies of this series. This site is marked as a volcanic centre on the map.

Stratigraphical Relationships.—The Lower Dacite Series may be seen in a hill section about ½ mile south-east of Lilydale, Allot 29^2, superposed on the Upper Toscanite Series, (*b*), and containing numerous fragments of the latter near the junction. It is, therefore, younger than (*b*). (See Plate XXX., Fig. 1.)

If anyone starts from Olinda Creek to climb the north flank of Mt. Dandenong, he will pass up in order over the following rocks: —(1) The Lower Dacite Series, finishing with the fragmental rocks named above, "the Dandenong Agglomerates"; next, (2), the

Middle Dacite Series; and, lastly (3), the Upper or Hypersthene Dacite Series, which is the normal Dacite. (Plate XXX., Fig. 3.) No cliff section of these junctions is known, but in every instance the above order of ascent was the observed order.

It is probable that in the first instance the junctions between these series occupied about the same level east and west right along the north flank of the range, but, owing to the downthrow of the Evelyn and the Olinda faults at its north-east extremity, the Middle Dacite Series (*d*) has been depressed to form the bed of Olinda Creek at that place, and the Upper Dacite Series (*e*) is also found at a low level in the fault valley. (Plate XXX., Fig. 2.)

Petrological Character.—This is a dark, slate-coloured, compact, brittle rock, showing phenocrysts of quartz freely, felspar less so, biotite in hexagonal flakes, pyrites and garnets occasionally, and numerous fragments, mostly igneous, the rest sedimentary.

Phenocrysts consist of quartz and orthoclase, idiomorphic, generally corroded, and often brecciated owing to flow movement. The quartz is more abundant than orthoclase, the latter often shows rhombic sections, with diagonal extinction. Plagioclase is subordinate to orthoclase, is idiomorphic, and apparently ranges from oligoclase to labradorite; biotite occurs in grains and flakes, bleached, and flexed by flow movement; garnet is common, often chloritised; iron oxide is seen in irregular grains, and there is also a secondary oxide associated with and derived from the biotite; apatite and zircon are present as accessories.

The ground mass is abundant, glassy to cryptocrystalline, and lines of flow frequently are well developed, with fragments of the phenocrysts corresponding thereto. Numerous inclusions of volcanic material and hornfels are present.

Chemical Composition.—In this rock the sub-alkali character is pronounced. It is much richer in CaO and MgO, and poorer in alkalis than the toscanite series. It has over 68 per cent. of SiO_2, and is, therefore, a dacite.

For these and other reasons, which appear later, this series has been called "The Lower Dacite Series."

d.—The Middle Dacite Series.

If we regard the Dandenongs as built up of three layers, then the present series (*d*) constitutes the second layer, except at the north-east corner, where it has been faulted down to stream level. It rises, abruptly, in most cases, above the "Dandenong Agglome-

rates,'' and is crowned by the Upper Dacite Series, (*e*). (Plate XXX., Fig. 3.)

Compared with the Lower Series (*c*), the rock is lighter in colour, more porphyritic, and therefore more crystalline, and it contains no fragmental material. It has fewer quartz phenocrysts, but in its earlier stages more felspar (plagioclase being greatly in excess of orthoclase, whereas in series (*c*) the reverse is the case), and ferro-magnesian minerals in about the same proportion.

It is distinguished from the Upper Dacite (*e*) by its abundant quartz and felspar phenocrysts, especially the former.

Towards the top of the series, i.e., approaching its junction with the Upper Dacite, the phenocrysts of quartz and felspar become fewer and much larger. The rock also becomes darker, and acquires a certain outward resemblance to the Upper Dacite. But notwithstanding this evidence of gradual differentiation within the series, there is no difficulty, except where landslips have masked the conditions, in drawing a sharp boundary line with the Upper Dacite. The two series are quite distinct.

Stratigraphical Relationship.—Wherever this series is in contact with the series *c*, the former occupies the higher level. Wherever it is in contact with the Upper Dacite (*e*), it occupies the lower level. This general testimony of superposition indicates that the order *c*, *d*, *e*, was the order of extrusion. For reasons given later, the Upper Dacite must be regarded as the last of the volcanic system, and the above order may be taken as confirmed.

Petrological Description.—The lower type is a gray rock, showing very numerous phenocrysts of felspar, quartz, and biotite, naming them in the order of decreasing abundance. The phenocrysts consist of quartz, idiomorphic, and often corroded; plagioclase (labradorite chiefly), zoned, idiomorphic, though often fractured, and sometimes containing small inclusions of sphene; orthoclase in clear rhombic crystals, extinguishing diagonally; plagioclase in excess or orthoclase; biotite, flexed into conformity with the flow lines; and pyroxene (?) much altered, identified mainly by the boundaries, giving extinction angles of 22 deg. to 39 deg. Garnet is common; apatite and zircon not uncommon; ilmenite accessory. The glassy ground-mass is obscured by myriad fragments of the phenocrysts, fractured by flow movements, and now arranged in conformity with the well-marked flow lines.

In the upper type of this series, quartz and felspar are in fewer but larger phenocrysts; deeply zoned plagioclase is still in excess of orthoclase; garnet is less abundant, if not absent; biotite is

more fragmentary, and intensely pleochroic. There is also a micaceous dust shimmering through a ground mass composed of a granular maze of quartz, felspar, and biotite, and a glassy residue. The flexure of the biotite and the corresponding arrangement of the other fragments indicate marked flow structure. Ilmenite is still abundant.

e.—The Upper or Hypersthene, or Normal Dacite Series.

This is the last and probably the greatest series of the system. Though occupying only the upper portion or crest of the Dandenongs in the north, it extends over 10 miles south, passing beyond the Gembrook railway line as far as the granodiorite, and at the same time spreading west as far as Lower Ferntree Gully, and east to Monbulk and Emerald.

This normal Dacite is distinguished from the preceding series thus:—Its porphyritic character is much less apparent, the phenocrysts being small, while quartz phenocrysts are very seldom seen; hypersthene is very abundant, though it appears to be quite absent from the preceding series, except possibly the first. Even in the series immediately underlying the normal Dacite, I have not found one occurrence of hypersthene. Orthoclase is present, but in a much lower ratio to plagioclase.

This dacite shows no difference from the Upwey dacite described by H. C. Richards (16), except that here rutile sometimes occurs in well-formed crystals.

Schistose Dacite.—In certain places, secondary biotite has formed in clusters, surrounding the hypersthene to some extent, and the ilmenite to a greater extent. At Mt. Dandenong this alteration is not easily noticeable, but going east towards the Evelyn fault valley, it becomes more marked, and on the highest part of the hornfels ridge, that forms the eastern wall of this valley, there are a few small residual patches of schistose dacite. Of these patches, one at least is almost, if not quite, isolated by the Silurian hornfels from the main mass of the dacite of the Dandenongs on the west of the valley. Other patches run down the eastern slope of the valley into the alluvium. It is clear, therefore, that the normal dacite rests on the Silurian as a lava flow. (See Plate XXX., Fig. 4.)

Origin of the Schistose Dacite.—These patches of dacite are not all equally altered. In some of them the schistose structure is emphatic; in others, it is scarcely perceptible in hand specimens. The following reasons present themselves for attributing their condition to plutonic and hypabyssal intrusions of granodiorite:—

1. The close proximity of intrusions of granodiorite porphyry in the subjacent Silurian, at lower levels than the schistose rock, suggests that the alteration is due to these and hidden plutonic intrusions.

2. The Silurians beneath the schistose dacite have been altered into hornfels, which is an extreme product of thermal metamorphism, and it is impossible to doubt that the altered dacite must be referred to the same cause as the hornfels.

Regarding the irregularity of the distribution of schistosity that has been noted in the small area under discussion, the prevalence of the big granodiorite dykes suggests the explanation that these anomalies are due to the unequal distance of the dacite from these intrusions, and possibly also to their unequal distance from the cooling surface.

B.—The Plutonic Phase.

The dacite forms a sharp junction with the granodiorite, south of the Gembrook railway line, and for six or seven miles along the contact, the former has been converted into a band of gneiss, penetrated in several places by veins of pegmatite and quartz. For these reasons, Prof. Skeats (13), in describing the above metamorphism of the dacite, concludes that the dacite is older than the granodiorite. Corroborative evidence obtained by Prof. Skeats at Macedon, Warburton, Nyora, and Marysville, confirms this conclusion.

Comparison of the chemical analyses of the dacite and of the granodiorite has shown that they are almost identical in composition, and are therefore referable to the same source, and to the same period, (13).

C.—The Hypabyssal Phase.

In the district shown on the map, two groups of dykes stand out prominently, one along the western border of the volcanic rocks, the other along the eastern border. The former group are characteristically basic, the latter intermediate in chemical composition. For reasons given below, the former are treated as differentiated, and the latter as undifferentiated dykes.

a.—The Differentiated Dykes.

These form a group of four along the western border of the system. They all penetrate the volcanic rocks, but two of them lie outside the area of the map. They may all be called Augite Olivine

Dolerite Dykes, but they fall into two pairs owing to a marked difference in structure, viz., ophitic and non-ophitic.

The Non-Ophitic Dykes comprise a dyke lying just outside the south-west corner of the area mapped, viz., in Allot. 48, and the dyke shown off Cambridge-road in Allot 23[a1]. The former has a width of at least 4 to 6 feet, and was traced for 50 yards, the latter is not less than 10 feet wide, and was traced for about 100 yards.

These are dark, fine-grained basaltic rocks, with no minerals discernible in hand specimens. Augite occurs in grains through the ground mass, and in larger crystals, with frequent twinning; olivine is now represented by its pseudomorphs. Iron oxide is very abundant, with shape and lustre of magnetite, but the prevalence of leucoxene-like alteration product suggests that the rock is titaniferous, and that some ilmenite is present. Laths of plagioclase (chiefly labradorite) are common, apatite occurs sparingly. Ground mass consists of granular matter set in cryptocrystaline to glassy base.

The Ophitic Dykes comprise a dyke in Allot. 40[b], and a dyke lying outside the map, where it penetrates a small residual of the series (*a*).

The former is a dark compact rock, showing large phenocrysts of augite, and long thin laths of felspar. This augite is green, generally zoned, and showing composite structure, often moulded on idiomorphic olivine, and penetrated by laths of basic plagioclase. Augite also in long purple, slightly pleochroic crystals, suggesting a titaniferous variety. Iron oxide is very abundant.

The latter is also a dark compact rock, but with much smaller crystals of augite and olivine. Its structure answers the description of the previous rock as far as the relations of augite, olivine and felspar laths to one another are concerned. But there is also an abundance of another mineral occupying interstices, mouded on the augite and olivine, and often enclosing the plagioclase laths. It has two cleavages, one perfect, is biaxial and negative, with low pol. colours, and a ref. index between 1.494 and 1.510, and does not gelatinise with H.Cl, though it is decomposed by it. It thus has the qualities of Stibite. Although it has the appearance of a primary mineral, especially as the rock shows no other signs of alteration, it certainly owes its origin to the pneumatolytic action of steam upon a ground mass whose remains are now only sparingly developed, and which was close to plagioclase felpar in its constituents and proportions.

In direction these basic dykes diverge a few degrees west of north, the divergence being greatest in the southernmost of them.

Regarding their *age*, it is difficult to decide whether they are related to the Devonian cycle or to the Tertiary basaltic eruptions. But the following considerations favour the former view:—

1. The neighbouring basalts contain no augite except in the ground mass, whereas the dykes are full of phenocrysts.

2. The close association of the dykes in each case with the Devonian igneous rocks.

3. The directions of the dykes are consistent with the hypothesis that they are part of a radiating system from some centre in the Dandenongs.

If this view be right, they must be regarded as differentiated dykes, representing possibly the complementary products of the acid lavas which appeared in the earlier part of the volcanic phase.

What appears to be a pair of complementary dykes is marked at the foot of the north slope of the Dandenongs in the Lower Dacite Series, adjacent to Olinda Creek in Allot 78. The two dykes outcrop within 10 yards of each other, but the outcrop is too limited to determine their direction.

The Basic Complementary dyke is a Dolerite. It is a bluish-black, tough, fine-grained rock, showing abundant pyrites. It contains laths and idiomorphic phenocrysts of plagioclase (mainly labradorite), and pseudomorphs of two other minerals, one apparently after a pyroxene, and showing ophitic structure, the other after olivine. Iron oxide is common, pyrites abundant, and calcite occurs in the vesicles. The ground mass is cryptocrystalline, and shows no flow structure.

The Acid Complementary dyke is a light gray porphyritic rock, crowded with phenocrysts of quartz, and streaked with small, elongated, white areas, due to the occupation of vesicles by secondary minerals. It contains phenocrysts of quartz, idiomorphic, but often corroded; orthoclase, with square or rhombic outlines and diagonal extinction; plagioclase (andes.-labrad.) ; biotite in flakes flexed in conformity with the flow lines, and often containing the sagenite web of rutite needles. Apatite and zircon in good proportions. Besides the orthoclase phenocrysts, there are also numerous orthoclases of similar shape, but of progressively smaller size, till those of the ground mass are reached, which is packed full of them.

Between Lilydale and Evelyn two dykes are visible in sections of the railway cutting, one (Allot. 26) about 20 feet wide, the other

(Allot 30^a), 5 feet wide. Both are much decomposed, the latter being now a soft, gritty rubble. Both strike about 3 deg. west of north.

b.—The Undifferentiated Dykes.

These dykes all occur either penetrating, or closely associated with, the remains of the igneous rocks that form a broken border along the eastern side of the Evelyn fault.

They fall into two divisions: (1) the Wandin dyke, (2) the granodiorite porphyries.

(1) *The Wandin Dyke.*—This dyke lies about $1\frac{1}{4}$ miles due west of Wandin (Allot. 33^a and 3) in the series *b*. It outcrops sporadically for $1\frac{1}{2}$ miles, and with an average width of about 45 to 50 feet. It bears a very close resemblance to the propylitized Dacite dyke of the Macedon district (one mile west of Hesket) (15). The chemical analysis of the latter is probably very close to that of the former, and has been used for that reason in the variation diagram, where it conforms very well with the curves.

This is a granitic-looking rock, with numerous phenocrysts of felspar and dark biotite, set in a fine ground mass.

There are large idiomorphic phenocrysts of zoned plagioclase, biotite, and probably another mineral now chloritised. Smaller irregular-shaped crystals of orthoclase are numerous. The rest of the rock consists of a micrographic intergrowth of quartz and orthoclase, which surrounds the phenocrysts. The plagioclase is sharply marked off from the eutectic corona, but the orthoclase often passes into it by a gradual transition. Apatite is common; zircon and magnetite are sparingly present. The granophyric structure, which is due to pneumatolytic action on the ground mass, supports Becker's suggestion, "that the ground mass of a porphyritic rock tends to approximately eutectic composition."[1]

(2) *The Granodiorite Porphyries.*—These form a group of dykes, lying west of South Wandin, on the high hornfels shoulder of the Dandenongs between Olinda Creek and the Evelyn fault. As the structure here contains several interesting features, a more particular description is given. (Plate XXX., Figs. 3 and 4.) The Evelyn fault is marked in this part by a deep depression, which develops into two valleys, one north, the other south of a small watershed in the depression. The dacite is sharply severed from the hornfels by these two fault valleys, except at the watershed,

1. See (19) p. 264.

where, and a little to the south of which, the Dacite is found lying on the top of the hornfels ridge, as much as 200 yards east of the fault. It differs, however, from the Dacite west of the fault in three respects :—

i. It forms residual patches on the hornfels.

ii. It is schistose, and in some cases intensely so.

iii. It is closely associated with the granodiorite-porphyry dykes, which occur in the hornfels at lower levels than the schistose dacite, and which, together with the plutonic mass they represent, are responsible for the production of the schists and hornfels. A boulder of the dyke rock was found in the gneissic dacite. But whether this was an included fragment, or the head of a hidden dyke, could not be determined. The presence of other dykes tends to favour the latter view. But, in any case, it is clear that the dykes, though possibly to a small extent simultaneous with the dacite, were in the main later than it.

These dykes are mineralogically similar, but they vary in the coarseness of the ground mass from a type about three times coarser than the Dacite up to a type where the minerals of the ground mass are nearly as coarse as the phenocrysts. This latter type is developed on a very large scale in a deep valley in north-east corner of block 920^b.

The following is a composite description of the commonest types found.

Phenocrysts of plagioclase are abundant, quartz not so common, biotite is abundant, and subordinate orthoclase. Biotite, associated sometimes with a little muscovite, is often arranged in radiating bunches.. Ground mass consists of quartz and orthoclase mainly, the latter often in square or rhombic sections, with diagonal extinction, but plagioclase, and flakes of biotite are also present. Apatite, zircon, iron oxide, and pyrite (intimately associated with biotite) are present as accessories.

Relation to the Dacite.—We may safely assume that these dyke rocks and the associated dacite were derived from the same magma basin. In the Dacite, the ground mass contains quartz and felspar in proportions of about 20 per cent. to 13 per cent. (16). In the dykes, this quartz and felspar form crystals whose size increases as the rock becomes more hypabyssal, until a type is reached where it is hard to distinguish the crystals of the second generation from those of the first. It, therefore, appears that the only true phenocrysts in these dykes, and possibly in the deeper-seated plutonic rock also, are the more basic felspars, some of the quartz and biotite, and

the accessories. The hypersthene, which is practically confined to the dacite or superficial rock, and even then is unstable in the presence of heat, changing over into biotite, is probably not a true phenocryst, but a crystal of the second generation, resembling, in this respect, the olivine of basalts,[1] which attains such a size owing to its power of spontaneous crystallisation, and to its rapid rate of growth.

Other undifferentiated dykes, viz., hornblende porphyrite, found by Prof. Skeats (13) near Aura, both in the granodiorite and in the dacite, are regarded by him as "genetically connected with the granodiorite, and as forming one of the later incidents connected with the plutonic rock."

The dykes marked on the map show indications of a radial arrangement with reference to some centre in the Dandenongs. Further observation of dykes on the south-west and south-east flanks of the Range are needed to be certain about it.

D.—The Volcanic Succession.

The following rock analysis have been made through the kindness of Mr. E. J. Dunn, by the officers of the Geological Survey Laboratory :—

	A	B	C	D
SiO_2	68.19	69.93	68.73	65.83
Al_2O_3	14.98	15.14	13.16	14.89
Fe_2O_3	0.74	1.30	1.17	0.73
FeO	2.74	2.33	2.74	4.63
MgO	0.29	0.26	1.22	1.88
CaO	1.95	1.80	3.03	3.13
Na_2O	3.34	3.36	2.30	2.12
K_2O	3.64	3.55	2.59	2.32
H_2O	1.40	0.83	1.86	2.41
$H_2O = (100°C)$	0.14	0.07	0.09	0.17
CO_2	1.93	nil	1.50	0.47
TiO_2	0.20	0.20	0.50	0.89
P_2O_5	0.05	0.03	0.17	0.16
Cr_2O_3	nil	nil	nil	trace
MnO	0.08	0 05	0.09	0.10
NiO	nil	nil	0.01	0.01
CoO	nil	nil	nil	nil
BaO	0.27	0.30	0.20	0.13
Li_2O	nil	trace	trace	nil
S	trace	trace	0.18	0.10

1. See (19) p. 218.

	A	B	C	D
SO_3	nil	nil	nil	nil
Cl	trace	trace	trace	trace
Total	99.94	99.15	99.54	99.97
Less O =	—	—	.07	.04
Total	99.94	99.15	99.47	99.93
Sp. Gravity	2.652	2.658	2.687	2.702

A. Lower Toscanite. Specimen from quarry 1m. N.E. of Lilydale, allot. 24, N. end.

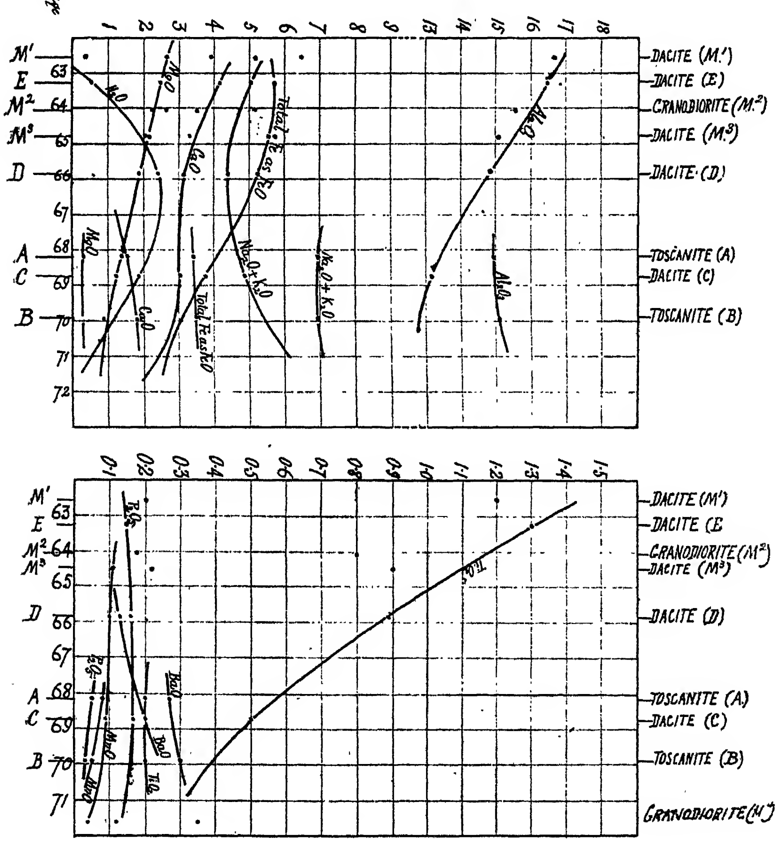
B. Upper Toscanite. Specimen from quarry about 1m. E. of Mooroolbark, allot. 22c.

C. Lower Dacite. Specimen from railway cutting between Lilydale and Evelyn, allot. 30c.

D. Middle Dacite. Specimen from Dandenong Range, N.E. flank.

Silica Percentage

Fig. 1.



Taking Richards' analysis (16) of the Hypersthene Dacite at Upwey, in addition to the above four, we are thus provided with a complete set, representing each of the five volcanic series. The variation diagram has been prepared from these analyses, and I have also introduced analyses of the following closely-related dacitic rocks of the Macedon district, described by Skeats and Summers (15), viz :—

M[1], Dacite, Braemar House.

M[2], Granodiorite, Braemar House.

M[3], Dacite, Hesket.

M[4], Grandodiorite, Baringo.

The petrological affinities of the Macedon and the Dandenong districts are indicated by the conformity of the analyses of the former with the curves of those of the latter, as far as the three Dacite Series (*c*, *d* and *e*) are concerned. These all form a serial group. The two toscanites (*a* and *b*), however, fall together on curves of their own. It is, therefore, obvious that either they have pursued an independent line of differentiation in the same cycle, or else, that they belong to some period older than the dacites.

In the absence of other evidence, I have preferred the former view for the following reasons :—(1) The distribution of *a* and *b* is such as to keep them everywhere in the closest association with the three other series. (2) The chemical analyses show family characteristics between the two groups, e.g., they both have a very high percentage of BaO, indicating probably a barium felspar throughout the four series; further, the series all fall in or near the sub-alkali division.

Order of extrusion.—The variation diagram shows that *a* and *b* form an inseparable pair. For reasons set forth earlier, *a* is regarded as being older than *b; c* has been found superposed on *b*. This gives us the order, *a*, *b*, *c*. For the reasons given below, *e* must be regarded as the last, and *d*, the penultimate, series of the cycle. Therefore, the order must be *a*, *b*, *c*, *d*, *e*, and this is the order which is everywhere indicated by the evidence of superposition.

Magmatic differentiation.—There appears to be little doubt that these five series, excepting possibly the toscanites, are consanguineous. They are, therefore, regarded as the differentiation products of a primordial magma, which there are the following reasons for believing to have had a chemical composition, similar to that of the Upper or Hypersthene Dacite Series (*e*), and the Granodiorite, and the Wandin Dyke :—

1. The above three rocks represent respectively the volcanic,

plutonic, and hypabyssal phases of the cycle, and they occurred in that order. The chemical composition of these three types is practically the same. It is clear, then, that after the extrusion of the first four series of the volcanic cycle, the magma remained unchanged, not only throughout the last series of the volcanic phase, though that series probably exceeds in magnitude all the previous ones added together, but also throughout the plutonic and hypabyssal phases to the end of the cycle.

2. These three types also bear the same relationship to one another in the Macedon district, where no differentiated rocks of the dacite family have been found.

3. There are immense developments of normal dacite, sometimes associated with granodiorite, in the neighbouring mountains between Healesville and Warburton, the Black's Spur, and the Cerberean Ranges.

With these reasons for regarding the Upper Dacite as representing the undifferentiated magma, there remain but four volcanic series which are differentiated, viz., *a*, *b*, *c*, and *d*.

By both mineralogical and chemical evidence these four series are resolved into two pairs. In the first pair (*a* and *b*) quartz is absent, except in the ground mass. In the second pair (*c* and *d*) it is abundant. In the variation diagram, the second pair fall with the Upper Dacite (*e*), the Granodiorite, and the Wandin Dyke, on the same curves. But the first pair fall on separate curves, being richer in SiO_2, Al_2O_3, and alkalis, but poorer in oxides of Ca, Mg, and Fe, than the second pair.

It thus appears that, if the toscanite be admitted to this cycle, there must have been an early separation of the magma into two parts.

One of these redivided, forming two magmas (*a* and *b*), almost identical in chem. composition, except that *a* was much richer in H_2O than *b*, with the result that though chemically similar, they are mineralogically different.

The other part, which was richer in basic constituents, and though poorer in SiO_2, contained much free quartz, divided into two series (*c* and *d*), such that the latter, containing more of the basic constituents, and more water, produced a rock more crystalline than the former, and containing less quartz, but more felspar and ferro-magnesin minerals.

Examples of the differentiation of andesitic magmas have been described by Judd (21), and by Teall and Lagorio. The latter observers remark that the order of crystallisation is such that the

magma becomes progressively more acid. In the Dandenongs, however, the order of extrusion was progressively less acid. This order is also exemplified in the Buchan district (12), where the L. Devonian igneous activity opened with quartz porphyries and rhyolites, and closed in some cases with andesites.

e.—Nomenclature of the Igneous Rocks.

There can be no doubt that a true classification ought to be genealogical, and it should also provide a nomenclature that would make it possible to give a generic name to all the members of any family of rocks, which have been produced by modification during descent from the same parent magma.

If we accept Hatch's classification, as it stands, then, in the case before us, the plutonic rock of the Belgrave railway line is too poor in SiO_2 [63.85 per cent. (Richards), and 64.41 per cent. (Plant)] to be called a granodiorite.

Further, taking the five volcanic series, the Upper series, hitherto called the "Hypersthene Dacite," would be the only one of the five which was not a dacite. No analysis has appeared, where its SiO_2 rises to 66 per cent. But, as all these series belong to one family, and that of obvious dacitic character, Hatch's boundary line should be elastic enough to enable us to give them all the same family name. Series *e* is therefore called the "Upper Dacite Series."

The first two series, containing nearly 7 per cent. of alkalis, and nearly 70 per cent. of SiO_2, form a pair of alkali dacites. As the ground mass of the first is full of orthoclase, while that of the later is microcrystalline, I proposed at first to name them respectively, "Orthoclase Alkali Dacite Series," and "Microcrystalline Alkaline Dacite Series." For the sake of simplicity, however, I have called them "The Lower," and "The Upper Toscanite Series," in conformity with the existing classification, though there is nothing in those names to indicate any consanguineity of these with the remaining three series.

In view of these two toscanites (alkali dacites), in which no quartz is to be seen except in the ground mass, where it is not greatly developed, it seems inadvisable to place too much reliance on Hatch's rule that dacites are mineralogically distinguished from andesites by the presence of quartz.

The last three volcanic series have been named for simplicity, "Lower," "Middle," and "Upper Dacite Series" respectively.

V.—Faults.

The map shows a narrow band of the series *b* along the western edge of the system, between the silurian, with which it forms a broken border on the west, and the series *c*, with which it forms a very regular junction on the east. This latter junction has such uniform persistence in direction over a course of seven miles, as to need explanation, especially as it is matched about two miles to the east by another very uniform, though arcuate boundary, which marks the eastern limit of the igneous system, and is for a large part of its course parallel to its western fellow.

Of these two junctions three explanations present themselves. They are either—

1. Natural boundaries, or,
2. Fold junctions, or
3. Fault junctions.

1. The first fails to explain in the case of either of them the uniformity of direction over a long distance, which contrasts so conspicuously with the many indisputable natural boundaries in the map. And when the two cases are taken together, its inadequacy is still more apparent.

2. Regarding the second, it has been shown that these igneous rocks lie unconformably on the upturned edges of the Silurians. If, therefore, the igneous rocks were involved in the folding processes, it can only have been to a small extent, so small that the resultant folds would be too shallow to account for the uniform junctions in question.

3. The evidence points strongly to the view that they are fault junctions. I have, therefore, interpreted them from this point of view, referring to the western junction as the Montrose fault, and the eastern one as the Evelyn fault.

The Montrose Fault.—This junction has been mapped for seven miles from the Salvation Army farm near Bayswater to Lilydale, and, excepting a small bulge westward, between Montrose and the Olinda Creek, its course throughout may be represented by a line which is very regular and persistent in direction. The junction is not visible all the way, but wherever it can be seen, it conforms to this line.

The series *b*, which lies along the west of the junction for the whole distance, may be seen outside of Lilydale, on the east of the junction, underlying the series *c*, which also contains many included fragments of it at its base. It follows, therefore, that if

the fault exists, the downthrow must have been on the east, where the younger rock, viz., series *c*, is preserved.

The Evelyn Fault.—The Montrose fault, which skirts the western wall of the Dandenongs, is matched along the eastern wall by another junction, which marks the igneous rocks off sharply against the silurians on the east. This junction passes Evelyn about half a mile to the east. From this point it runs a little east of north, keeping parallel with the Montrose fault, two miles away to the west, and like it, separating the series *c* on the west from series *b*, or, where this has been denuded away, from the Silurians, on the east. Tracing it south from Evelyn (Plate XXX., Figs, 4, 5), it ends abruptly at the Olinda Creek, but starts again some 250 yards to the east, whence it runs in a direction a little west of south, cutting across the eastern shoulder of the Dandenongs, and severing dacite from hornfels. After trending about half a mile in this manner, it bears east again, and recovers a course which would conform with the arcuate continuation of the junction, if it had crossed Olinda Creek directly. It therefore appears to have been faulted out of its path at the Olinda Creek.

The path of the junction across the Dandenongs is marked by a deep depression, referred to in this paper as the Evelyn Fault Valley. For half a mile south of Olinda Creek, this depression is steep and narrow. (Plate XXX., Fig 4a, Sect. AB). Further south, it forms an equally deep but very broad valley, the two valleys being separated by a small watershed in the depression. (See Fig. 4a, Sect. CD.) The broad valley opens out southward upon the upper course of Olinda Creek. I have not traced the junction south of this point, but on consulting a map of the Woori Yallock basin, by J. Easton, whose map practically begins where mine ends, it appears that if this line is continued in the same direction to Monbulk, it will still mark off the dacites on the west from the silurians on the east. On the other hand, if the junction were continued at its northern extremity, across the Yarra, it would pass along the eastern wall of the western pair of quartzite ridges described earlier. (Plate XXX., Fig. 5.) The Stringy Bark Creek, on crossing this junction in its north-west course, is immediately lost in a wide marsh. The Yarra also, on crossing the place where this junction would occur, expands into an extensive marsh on the left bank.

Here then is a line separating various kinds of rock, and yet maintaining a uniform arcuate direction for many miles. Evidence of depression on the west of it exists at Olinda Creek. (Plate

XXX., Fig. 2), and also, if we regard it as continued to the Yarra, in the two marshy areas above referred to. The theory that it is a normal junction, though satisfactory for section CD, across the Fault Valley above referred to, appears to be inconsistent with section AB, where the valley is not broad, but deep and narrow, the junction being nearly vertical. The fault theory is therefore supported, not only by the persistence of direction, and the evidence of depression on the western side, bot also by the nature of this valley, which I have therefore called the "Evelyn Fault Valley."

The downthrow of this fault would be, of course, on the west, where the younger rocks are in every case preserved.

Taking the combined high probabilities of the Montrose, and the Evelyn faults, it is difficult to avoid the conclusion that a large rectangular block, including at least the northern part of the Dandenong mountains, has foundered between these two fault planes. (Plate XXX., Figs. 1 and 3.)

Some six months after I had mapped the northern part of the Montrose fault, Mr. J. T. Jutson published his valuable paper on the Physiography of the Yarra (18). He postulates, though, with a query, what he calls the Dandenong fault, running along the western edge of the Dandenong Range, in the path of the Montrose fault, and continuous in the south with the fault discovered by Sir A. R. C. Selwyn, near Frankston (18). He also continues the Brushby Creek fault southwards in the same manner. Between these two fault planes, he believes, a block has been relatively depressed, producing in the South the Carrum Swamp, and a portion of Port Phillip, and in the north, the Croydon Senkungsfeld.

The fresh evidence educed in this paper points to the need of certain modifications of this theory:—

The Croydon Senkungsfeld has been relatively depressed, as he says, against the Brushy Creek fault scarp, but not against the Dandenong Mountains. On the contrary, if the senkungsfeld extends so far east, then the Dandenongs have been faulted down against the senkungfeld. Since the relative depression occurred, not on the west of the fault plane, as Mr. Jutson has postulated, but on the east, the Dandenongs possess their present height, not because of these dislocations, but in spite of them. For this reason I am unable to agree with Mr. Jutson's theory of a Dandenong fault, forming the eastern boundary of the Croydon Senkungsfeld.

Seeing that there is very probably at least one fault (Montrose fault), coasting the western wall of the Dandenongs, it remains to

consider whether, although it be the reverse of what Mr. Jutson postulated, it may not, as he believes, by a northern continuation of Selwyn's fault. If it may, then we must imagine a see-saw movement on an east and west axis, south of which, if the beds were depressed, then north of it they must have been elevated, and vice-versa.

Now, this see-saw movement could have occurred on the east of the fault pane, or on the west of it. It did not occur on the west of it, for the senkungsfelder in the north, and the Carrum Swamp in the south, indicate a depression at both ends of the block. It can only have occurred, therefore, if it occurred at all, on the east of it, the sinking of the Dandenongs in the north being balanced in the south by a rising of the granitic areas of Mornington peninsula.

The presence of the small basalt-capped plateau lying west of Cave Hill, Lilydale, suggests the possibility of its being the eastern boundary of the Croydon Senkungsfeld. In this case, if the boundary were determined by a fault, that fault would lie one and a half or two miles west of the Montrose fault.

The Olinda Fault.— It has already been noted that where the Evelyn fault meets Olinda Creek, it appears to have been heaved out of its course about 250 yards to the east, with the result that the series *d* is now found at the foot of the high cliffs of hornfels and series *c* on the north bank of Olinda Creek, which occupies the junction. (Plate XXX., Fig. 4.) The existence of this Olinda fault is supported by all the evidence in favour of the Evelyn fault. If, therefore, the latter be taken as established, the former must be also. The downthrow was on the mountain side, where the igneous rocks are preserved against the silurians.

Above the Evelyn fault, the Olinda Creek valley is very young. It is marked by rapids and waterfalls, the latter having receded more than one mile above the fault. Below the fault the valley widens, so that the stream meanders through wide alluvial flats. This rejuvenation of the stream has probably resulted in its capturing much of the headwaters of Stringy Bark Creek.

VI.—The Tertiary Igneous System.

I have taken Stirling's boundaries for the basalt. The basalt lies upon the silurians, capping a small plateau west of the railway line, between Lilydale and Mooroolbark. At Cave Hill it occupies an old river channel, whose sands lie between it and the limestone.

Here it is limited by the quartzites, which evidently formed the eastern bank of this channel. It nowhere transgresses the igneous rocks of the Devonian cycle to the east, which probably formed high ground when the basalt was poured out.

Macroscopically, it is a dark, non-vesicular, very tough, fine-grained rock, with small crystals of green olivine.

Microscopically, olivine is abundant in large, regular crystals, and a few large laths of a basic plagioclase are set in a ground mass, composed of felspar laths, lath-shaped augite, granular olivine, and abundant rectangular magnetite, and interstitial glass.

The reference of this basalt to the older or newer series is by no means easy. Petrologically two criteria are used, viz. :—

Both tests are inconclusive, but they tend to place the Lilydale basalt in the older series. In the quarry north of Cave Hill, in allot. 30 1, the basalt is very decomposed. Added to this, the extensive circumdenudation, which is apparent, tends to favour the older age.

Source.—Till now, no undoubted vent of the older basalt has been found. At Lilydale, in the basaltic plateau, just referred to, there is a crater-like depression breached towards the north-east, which being regarded as a vent by the residents, is therefore known as "Crater Hill." Sections on the adjoining roadside resemble tuffaceous deposits. On the opposite side of the road, there is another larger depression opening on the north-west side. In a hole sunk in the bottom of this basin to a depth of about thirty feet, the basalt is present all the way. The rock on the rim of the basin has all the appearance of a decomposed fragmental rock. Further evidence is needed, before concluding that the place was an eruptive centre.

In conclusion, I wish to thank Professor Skeats, who has discussed the problems with me from time to time, both in the field and in the laboratory; also Mr. H. J. Grayson, for kindly preparing the micro photographs, and some very thin rock sections; and also Mr. E. J. Dunn, who permitted me to have four rocks analysed by Messrs. Bayly and Hall, in the geological Survey's laboratory.

VII.—Summary.

The following are the most important new results contributed in this paper :—

1. The district between Lilydale and Mount Dandenong has been mapped petrologically for the first time, with the exception of the

narrow strip from Lilydale across Cave Hill, which was done by V. R. Stirling. Some of his boundaries, and those of the geological map of Victoria, published by the Geological Survey Department, have undergone important alterations during revision.

2. A denuded synclinal fold of the Yeringian (U. Sil.) series forms the basal rock of the district. Their strike is normally north and south, but in the area north-east of a line joining Lilydale and Evelyn, it is diverted 40 deg. or 50 deg. to the east.

The prevalence of littoral facies probably marks the close of the silurian invasion.

The alteration of some facies into quartzite has been caused, not by thermal metamphorism, but by metasomatic processes, aided probably by folding stresses.

3. Upon this sedimentary floor, lies a stack of igneous rocks, which have been linked up into one system with those of the Dandenong Ranges.

These rocks are regarded as representing the volcanic phase of an igneous cycle, which was completed by plutonic and hypabyssal phases.

Representative specimens selected from the three phases have been described and compared.

The volcanic rocks are resolved into five series, and these series are regarded as being consanguineous.

The chemical composition of the first four series was determined by means of analyses specially made by Messrs. Bayly and Hall.

Variation diagrams have been made from these and other analyses of rocks, selected from each of the three phases of the cycle.

The bearing of this evidence on the differentiation of the parent magma is discussed. The differentiation was progressively less acid.

The composition of the parent magma of the differentiated volcanic series is shown to be represented by the last series of the phase (viz., Hypersthene Dacite), which remained on the whole unchanged throughout the plutonic and hypabyssal phases of the cycle. It was sub-alkali, and between acid and intermediate in composition.

Of the volcanic series, the first four, which are differentiated, fall naturally into two pairs:—

(i) A pair of toscanites (or alkali dacites). These are chemically identical, but mineralogically dissimilar.

This difference is attributed to mineralisers (especially H_2O), present in the Lower, but absent from the Upper.

(ii.) The second pair have a sub-alkali composition, and are named Lower and Middle Dacite Series respectively. They differ chiefly in the ratio of ground mass to phenocrysts.

The Middle Series was followed by the Upper or Hypersthene Dacite Series, which brought the volcanic phase to an end.

All the rocks of the system, except the two toscanites, conform to the same serial curves in variation diagram. The toscanites fall on curves of their own. The question is, therefore, raised, whether they should be admitted to the cycle, or referred to some earlier date.

Evidence is presented for the sites of two eruptive centres, which are marked on the Map.

Evidence of foliation in the two toscanites, together with its absence from the remaining series is discussed especially with reference to the Devonian folding movements.

The dykes are of two kinds, differentiated and undifferentiated. There are signs of radial groupings with reference to some centre in the Dandenongs.

The undifferentiated dykes appear to be closely associated with the plutonic rock, which occurs, on the one hand, about one mile south of the Belgrave railway line, where it outcrops extensively, and, on the other hand, on the eastern shoulder of Mt. Dandenong, where it is invisible. In both cases it has converted the contiguous dacite into a schistose type, and in the latter case, it has also converted the Silurians into a hornfels, and has sent out large apophyses, which outcrop in the hornfels below the schistose dacite.

This residual patch of schistose dacite, resting upon the hornfels is clear evidence of the volcanic nature of the Hypersthene Dacite.

The type of alteration here is similar to that, described by Prof. Skeats, in the district south of Upwey and Belgrave.

"The Wandin Dyke" shows a type of propylitization similar to that near Hesket (Mt. Macedon), and described by Skeats and Summers.

In a dolerite dyke near Mooroolbark the ground mass has been secondarily altered to stilbite.

4. Evidence is discussed for placing a fault along each of two long uniform junctions, running parallel (N.E. and S.W.) for some distance, one east, the other west, of the Dandenongs. There seems little reason to doubt that a great block, including the northern part of the Dandenongs, has subsided between these two fault-planes. Evidence is presented for another fault—the Olinda fault.

5 The influence of these faults on the physiography of the district is described.

6 The tertiary basaltic eruptions are represented by a patch of olivine basalt, capping a small residual plateau about one mile west of Lilydale. This rock is described, and its age is discussed.

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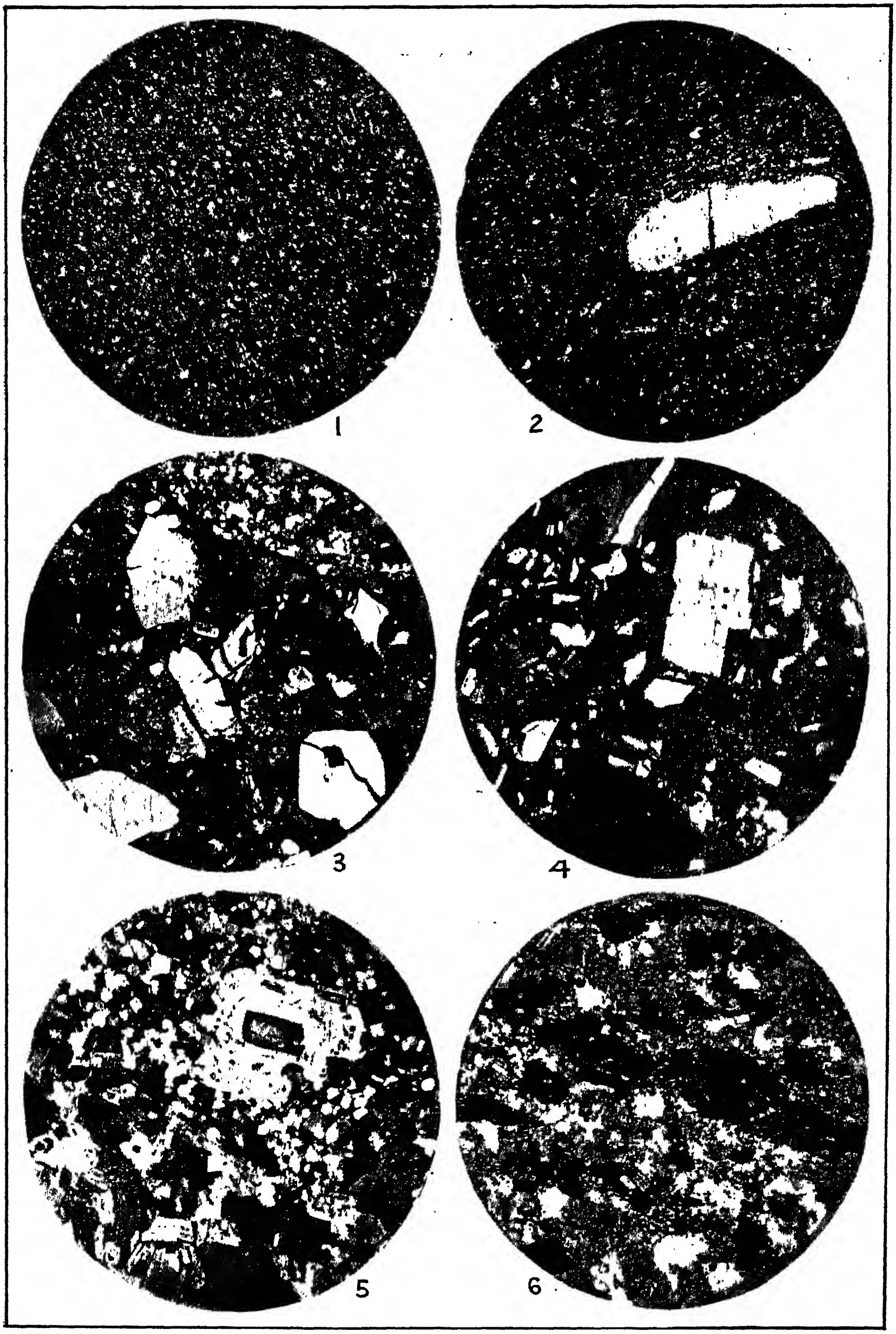
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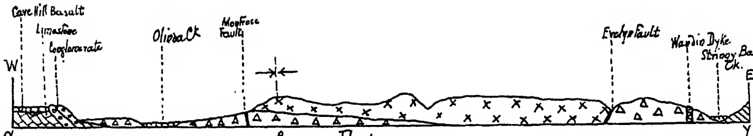
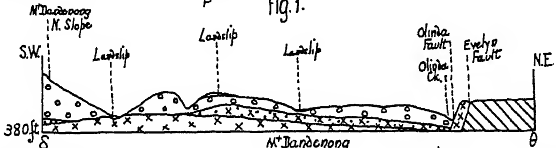
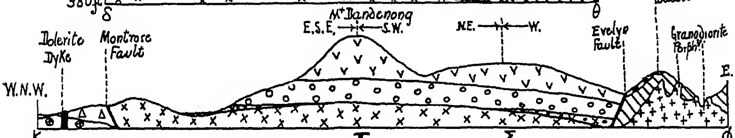


Fig. 1.

Fig. 2.





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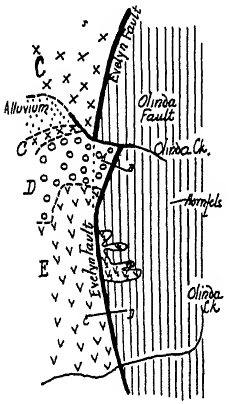

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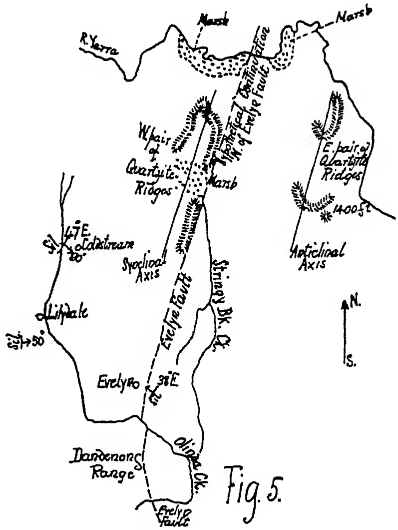

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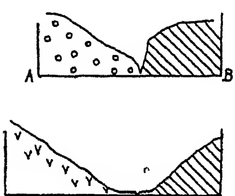

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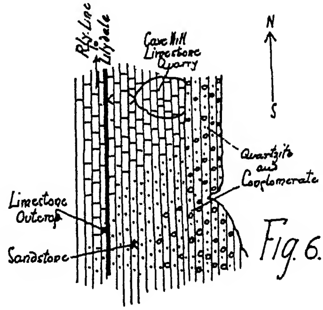

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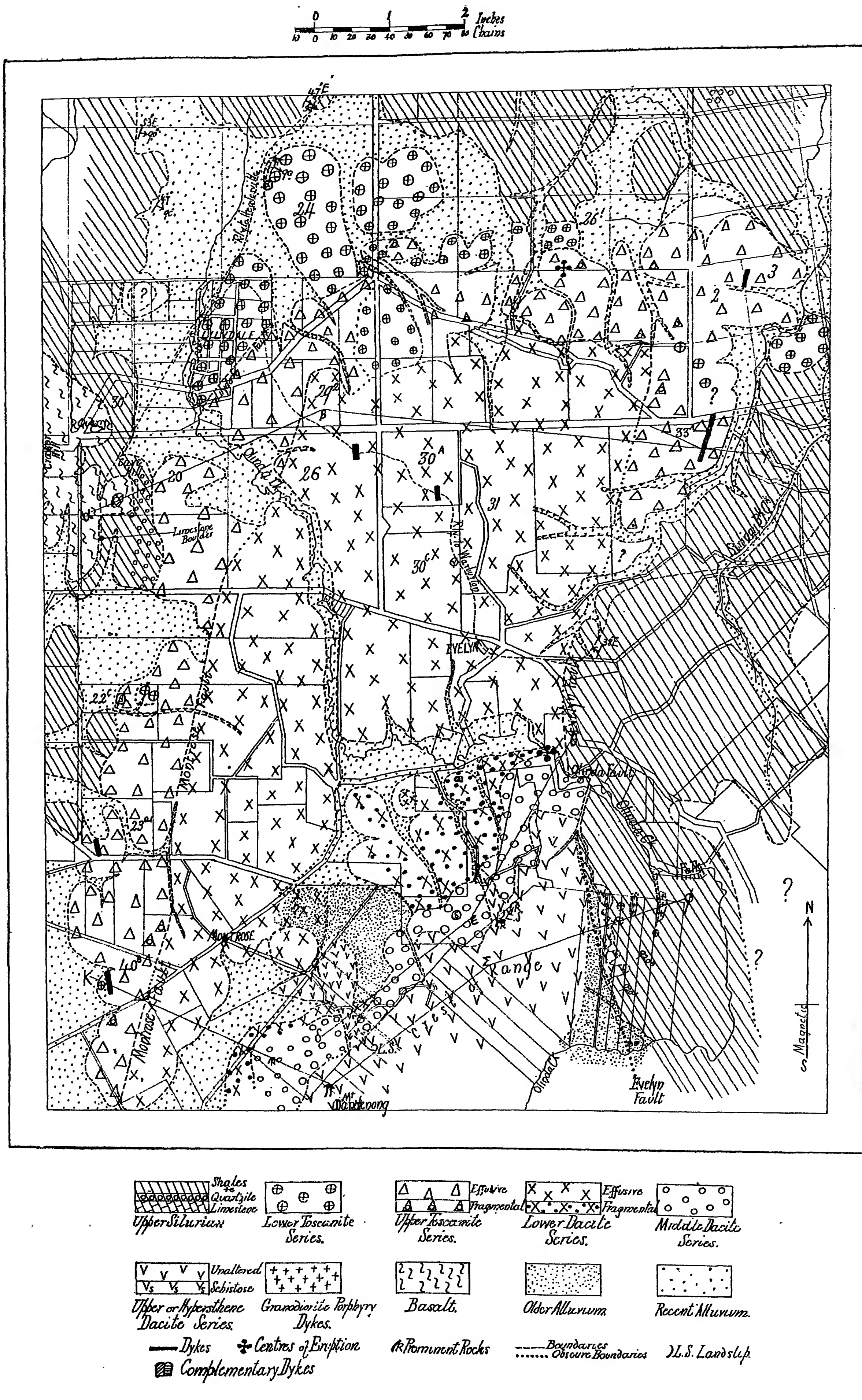

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IX.—DESCRIPTION OF PLATES.

Plate XXIX.

Fig. 1.—Photomicrograph of the Lower Toscanite Series, × 29, polarised light, showing ground-mass composed of orthoclase, and microlites of plagioclase, the latter with parallel arrangement.

Fig. 2.—Photomicrograph of the Upper Toscanite Series, × 29, polarised light, showing microcrystalline ground-mass, and the parallel arrangement of the phenocrysts of plagioclase with the few microlites that occur.

Fig. 3.—Photomicrograph of the Lower Dacite Series, × 21, polarised light, showing fractured phenocrysts of quartz, orthoclase, plagioclase, and biotite set in a glassy base; also showing an included fragment of hornfels.

Fig. 4.—Photomicrograph of the Middle Dacite Series, × 21, polarised light, showing phenocrysts of quartz, felspar, and biotite, in a fine ground-mass, shimmering with biotite.

Fig. 5.—Photomicrograph of a granodiorite porphyry dyke, × 21, polarised light, showing phenocrysts of biotite and zoned plagioclase set in a coarse dacitic ground-mass.

Fig. 6.—Photomicrograph of the Schistose Dacite, × 21, polarised light, showing the hypersthene in process of alteration to biotite, and the foliation of the latter.

Plate XXX.

Fig. 1.—Transverse section from Cave Hill to Stringy Bark Ck., showing the relations of the Silurians to the Older Basalt, and to the two toscanites; the Montrose and the Evelyn faults, and the Wandin dyke.

Fig. 2.—Transverse section along the northern slope of the Dandenong Range, showing the absence of fragmental facies at the foot of Mt. Dandenong, and the relations of the rocks at Olinda Ck.

Fig. 3.—Transverse section across Mt. Dandenong (summit), showing all the series of the vocanic phase, the relations of the schistose dacite to the hornfels and grandiorite porphyry intrusions, and the Montrose and the Evelyn faults.

Fig. 4.—Map illustrating the course of the Evelyn Fault over the Dandenong Range.

Fig. 4a.—Diagrammatic transverse sections of the Evelyn Fault Valley at the places marked in Fig. 4.

Fig. 5.—Map to illustrate the Gruyere Quartzite Ridges and other physiographical features.

Fig. 6.—Map to illustrate the probable relations of Limestones and Sandstones beneath the Basalt at Cave Hill, near Lilydale.

Plate XXXI.

Geological map of the area between Lilydale and Mount Dandenong.

[PROC. ROY. SOC. VICTORIA, 26 (N.S.), PT. II., 1914].

ART. XXIII.—*The Essential Oil from the leaves of Agonis flexuosa.*

BY R. E. PARRY, B.Sc.

(Victorian Government Research Scholar).

[Read 11th December, 1913].

Agonis flexuosa, D.C. (N.O. Myrtaceae) is a tree of low but very foliaceous appearance abounding in South-Western Australia, where it is known as "Willow Myrtle," or sometimes as "Peppermint."

Being somewhat ornamental, it is frequently grown in streets with species of eucalypts.

The narrow, coriaceous leaves are covered with numerous oil-glands, and when crushed emit an odour similar to that from many species of eucalpts.

Baron von Mueller in describing this tree in his "Select Extra-Tropical Plants," mentions that it yields an oil of "high antiseptic value," but no record has been found of any systematic examination of this oil, and the present paper aims at doing for this important oil-yielding tree what has already been done for most of our eucalypts.

By courtesy of Mr. J. Cronin, the director, supplies of the leaves were obtained from the Melbourne Botanic Gardens. Although the trees there are not in their natural habitat, the conditions of growth were not considered sufficiently abnormal to have any appreciable effect on the oil; in fact, it is probable that, as in the eucalypts, species is the main factor determining the character of the oil, and that climate, soil, etc., have but little effect. The age of the tree and the season of collection do, however, appear to have some slight influence on the yield and composition of the oil.

For this reason supplies of leaves were obtained at different seasons of the year; the first in March, 1913—early autumn—and the second in July, 1913—mid-winter. The former was distilled the day after cutting, and the second after a delay of about a week. This delay has been shown, by experiments carried out in connection with a similar investigation, to be of much less consequence than might be supposed.

Altogether about 17 ounces of the oil were obtained from the distillation of slightly over one hundredweight of leaves, and the yield, physical properties and composition of the two samples showed only insignficant differences. [Vide Table I.]

The Crude Oil.

The crude oil is of a greenish colour, closely resembling in appearance that of *E. globulus*, but its odour is quite distinctive, suggesting cineol, cymene and a phenol as some of the constituents. It is soluble in less than its own volume of 80 per cent. alcohol, but requires four volumes of 70 per cent. alcohol.

In addition to the two above-mentioned samples of oil, a third, distilled some 32 years ago, and which was possibly the sample described by Baron von Mueller, was obtained from the Botanic Gardens Museum.

TABLE I.

Physical Properties of Oils from Agonis flexuosa.

Oil.	Date of Collection.	Yield.	$\alpha 15°$	$\mu 15°$	$\delta 15°$	Cineol.
I.	March, 1913	1.0°/o	+5.3°	1.4657	.900	72.2°/o
I(a).	March, 1913	—	+5.3°	1.4654	.905	72.5°/o
II.	July, 1913	0.8°/o	+4.6°	1.4701	.908	62.0°/o
III.	About 1881	—	+3.8°	1.4686	.917	79.1°/o

Oil I(a). is a portion of oil I., from which the phenol has been removed. The cineol has been estimated by absorption in a saturated aqueous solution of resorcin—a method that has proved more satisfactory in our experience than the older phosphoric acid method.

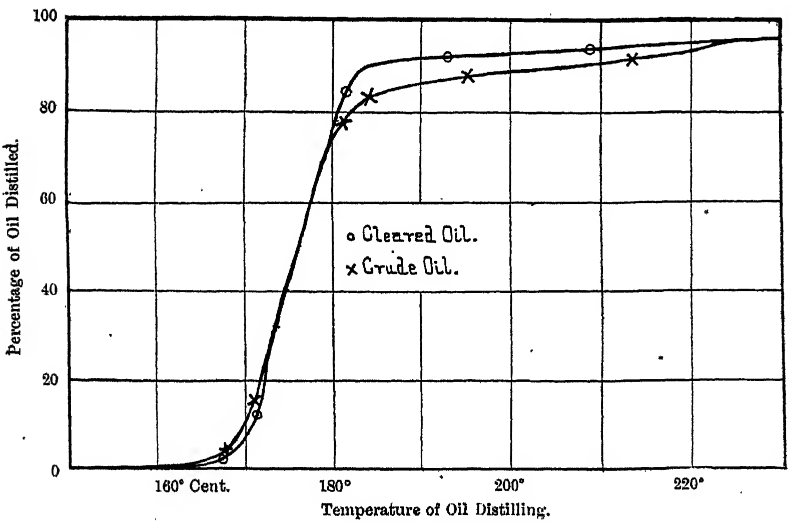
Cleared Oil.

The first sample of oil obtained—the autumn collection—was then investigated.

Phenols.—It was first treated to remove phenols. To do this 125 c.c. of the oil were shaken with a normal aqueous solution of sodium hydroxide until the phenols were dissolved; the aqueous solution was then separated, shaken out with ether to remove adhering oil, and then acidified. The separated phenols were extracted with ether and evaporated to a constant weight. The phenol was a dark yellowish-brown liquid, with a smell, strongly suggesting creosote. It was almost insoluble in water, but dissolved easily in 80 per cent.

alcohol. The addition of aqueous ferric chloride solution to this alcoholic solution produced a red coloration. Also a drop of strong nitric acid, added to a weak aqueous solution, caused a magenta coloration. There was, however, insufficient phenol to allow of any further examination.

Aldehydes.—The next step in the examination was the isolation and identification of aldehydes. The oil, after the removal of the phenol, was well washed with water and then treated with a saturated aqueous solution of sodium bisulphite, with repeated shakings for several hours. No crystalline compound was formed, and the aqueous portion on investigation showed no traces of any aldehydic compound having been formed. Similar examinations of the fractions boiling below 170 deg. C. and above 190 deg. C. respectively also gave negative results, so there can be no doubt that aldehydes, so often occurring in and depreciating the value of eucalyptus oils, are absent from this oil.



Fractional Distillation.

To isolate, as far as possible, the remaining constituents of the oil, fractional distillation was resorted to. The cleared oil was fractionated to identify the substances present in the oil. The crude oil was also fractionated and the physical properties of the fractions examined [vide Table II.]. The accompanying graph shows the distillation curves for both crude and cleared oils.

TABLE II.

Physical Properties of Fractions.

Fraction	Temperature	Volume of Fraction	$\alpha 15°$	$\mu 15°$	$\delta 15°$	Cineol. Content of Fraction.
I.	below 170°	5.5 c.c.	—	1.4641	.893	2.7 c.c.
II.	170°-174°	12.0 c.c.	+8°.1	1.4649	.897	7.7 c.c.
III.	174°-178°	13.0 c.c.	+3°.0	1.4650	.906	9.1 c.c.
IV.	178°-187°	12.0 c.c.	+0°.8	1.4658	.911	8.6 c.c.
V.	187°-227°	5.5 c.c.	—	1.4738	.916	6.1 c.c.
VI.	above 227°	2.0 c.c.	—	—	—	0.8 c.c.
	Whole Oil	50.0 c.c.	+5°.3	1.4657	.900	35.0 c.c.

A table of this kind is extremely useful in pointing out possible constituents. For instance, fraction IV. is practically optically inactive, and yet on determining its cineol content we have accounted for only two-thirds of the fraction. This suggests the presence of another optically inactive substance of about the same boiling point as cineol, and further investigation confirms this.

Identification of Chief Constituents.

Cineol.—As stated earlier, the camphoraceous odour of cineol is noticeable in the crude oil. To confirm its presence, syrupy phosphoric acid was poured on to the oil in a test tube—equal quantities of each—and the mixture shaken up and held under a running tap for a minute, when it solidified, proving the presence of cineol. This test also proved the absence of aromadendrene, as the solid was white, for, if it were present, a brownish-red coloration would have been produced. For the quantitative estimation of cineol, the resorcin method was used. The results obtained were:—In whole oil, 72.2 per cent. In fractions, 70 per cent. A phosphoric acid estimation was also carried out, giving slightly lower results, but not sufficiently different to cast any doubt on the more consistent resorcin results.

Pinene.—Fractions I., II. and III. of the cleared oil was separately decineolised by resorcin. The residues from fractions I. and II. had distinct pinene odours, and were therefore tested for pinene thus: 2 c.c. of the oil were cooled; 7 c.c. of Amyl nitrite were added and then 4 c.c. of glacial acetic acid. The mixture was then cooled with ice and kept cooled while equal parts of glacial acetic acid and concentrated hydrochloric acid were added, drop by drop, with stirring, as long as the liquid was blue in colour. Crystals gradu-

ally separated out until there was a fairly heavy preciptate of pinene nitrosochloride, proving the presence of pinene in the oil.

Cymene.—The residue of fraction III., above mentioned, consisting of 3.5 c.c., had a lemon-like odour, strongly suggestive of cymene. It was oxidised by heating on a water-bath with 6 gms. of potassium permanganate and 180 gms. of water, until the reaction was complete, shown by the absence of oil on the surface of the aqueous solution. The oxide formed was filtered off and evaporated to dryness. The potassium salt was then boiled out with alcohol and evaporated, the residue being dissolved in water and acidified. The separated acid was re-crystallised from alcohol and melted at 155 deg. C., thus showing that it was p-oxyisopropyl-benzoic acid, and thereby proving the prior presence of cymene in the oil.

No Phellandrene.—Phellandrene is absent, a fact proved by the following test :—2 cc. of the oil were taken, and 3 c.c. of saturated aqueous solution of potassium nitrite were added, without mixing. Then ten drops of glacial acetic acid were slowly added, and the test tube, containing this, put aside to stand. No crystals formed, therefore there is no phellandrene in the oil.

Esters.—The saponification number found by the usual method is 7.5, which is equivalent to 2.6 per cent. of an ester, having the composition $C_{10}H_{18}O$.

Alcohol.—Acetylation by the ordinary method gave 7.6 per cent. of an alcohol, having the composition $C_{10}H_{18}O$.

No Free Acid.—There is no free acid in the oil, which is shown by shaking a known weight of the oil with a measured quantity of alcoholic sodium hydroxide solution for a minute and then titrating back with a standard acid.

Summary.

The main constituents of the oil are, therefore, cineol, cymene and pinene. It also contains small amounts of alcohol, phenol and ester, but no phellandrene, aromadendrene, aldehyde or free acid.

It has a very pleasant odour, and owing to its high content of cineol, should prove commercially valuable. The abundance of trees in certain districts, and their foliaceous habits of growth allow of an extremely economical collection of leaves. The percentage yield, though not high, is sufficiently large to make a payable proposition, and so, taking all these factors into consideration, there is scope for the development of a new industry in South-Western Australia.

The supply of leaves in Melbourne unfortunately being restricted, this investigation was not so complete as the author should have wished; but if this paper causes an increased interest in a well-known but little investigated tree and its products, he will feel amply repaid.

Finally, he has to thank Professor Masson and Dr. Heber Green, of the Chemistry Department, University of Melbourne, for the kindly interest taken and generous assistance given in the prosecution of this research.

[PROC. ROY. SOC. VICTORIA, 26 (N.S.), PT. II., 1914.]

ART. XXIV.—*On a Volcanic Agglomerate, containing glaciated pebbles, at Kangaroo Gully, near Bendigo.*

BY ERNEST W. SKEATS, D.Sc., A.R.C.S., F.G.S.

(Professor of Geology and Mineralogy, University of Melbourne.)

(With Plate XXXII.)

[Read 11th December, 1913.]

Introduction.

This communication is concerned with the nature and origin of a remarkable rock outcropping in Kangaroo Gully about four and a-half miles S.W. of Bendigo. My attention was first called to it, and some of its peculiarities described to me by one of my former students, Mr. E. C. Dyason, B.Sc., B.M.E., towards the end of the year 1905. In his company and that of Mr. H. S. Whitelaw, of the Geological Survey of Victoria, I visited and examined the locality in January, 1906. A second visit was made by Mr. Dyason and myself in March, 1906. In 1907 and again in 1911 I revisited the area, and completed the field observations recorded below. I have delayed publication in the hope that further field work and reflection might enable me to give a satisfactory explanation of the origin of the occurrence. A completely satisfactory solution of all the problems has not occurred to me, but as the sections exposed in the gully are becoming more obscure, I now place the facts on record before the opportunity for other geologists to examine the exposures in the field is lost.

Previous Literature.

In 1873 Mr. Reginald Murray made a sketch geological map of the Sandhurst (Bendigo) district, which included the area under discussion. The alluvial gold-bearing deposits of Kangaroo and Opossum Gullies are indicated on all copies of the map, but the copy in the geological department of the University shows no indication of the conglomerate or agglomerate. A copy in the Geological

Survey Office at Bendigo, however, shows the boundaries of the conglomerate approximately defined.

The only written account of the conglomerate I have been able to find occurs in the Report on the Bendigo Gold Field, page 6, by Mr. E. J. Dunn, F.G.S., published by the Geological Survey of Victoria in 1892, and a second part in 1896. As Mr. Dunn's description, though important, is brief, I record it in full. It is headed, "Glacial Conglomerate":—

"On the west side of Kangaroo Gully, and opposite Opossum Gully, an outlier, a few chains in length, and from one to two chains in width, of conglomerate that is referable to the same age as the Wild Duck Creek conglomerate, occurs; it does not appear to be of any great depth, and in age may be of Permian or later date. In a more or less clayey matrix, in part rudely stratified, and in indurated fine gravel are well rounded masses of quartzite derived from Devonian conglomerates, hard grey sandstones in angular blocks, small fragments of schist, etc., the pebbles and fragments with the larger axes as frequently nearly vertical as horizontal. Veins of pale yellow chalcedony occur, penetrating the clayey matrix; no other outlier was noticed in the vicinity of a similar character. The conglomerate is very distinct from and in no way to be confounded with the tertiary conglomerates; it is the last vestige of what may have been a very extensive deposit."

Mr. F. L. Stillwell, M.Sc., in a paper on the monchiquite dykes of the Bendigo goldfield. Proc. Roy. Soc., Vic., Vol. xxv. (New Series), Part 1, 1912, p. 9, in discussing their age, refers to one dyke cutting the conglomerate of Kangaroo Gully.

In view of the volcanic nature of the matrix of this occurrence at Kangaroo Gully, it is interesting to note that some of the earlier geologists in South Africa described the Permo-Carboniferous glacial comglomerate (the Dwyka conglomerate) as of volcanic origin.

A. G. Bain, in Q.J. Geol. Soc., 1845, p. 315, described the rock as a claystone-porphyry, and believed it to be the product of an enormous volcano. D. Draper, in Q.J. Geol. Soc., Vol. 50, 1894, pp. 554-555, discussed the origin of the Dwyka conglomerate, and quoted a letter from Dr. G. A. F. Mobengraff, in which the latter stated that he had studied the rock "in situ," and by microscopic sections. He said: "The Dwyka conglomerate gives me the impression of a volcanic tuff (I mean a probably Permian diabase-tuff) full of fragments of older rocks."

The hypothesis of the volcanic origin of the Dwyka conglomerate is now, I believe, entirely abandoned in favour of a direct glacial

origin. Rock sections which I have made from material collected by me at Riverton, near Grahamstown, and elsewhere in South Africa, certainly contain pebbles of igneous rocks, but the matrix is free from volcanic material, and has the angular and typical characters of a normal glacial conglomerate.

Position of the Deposit.

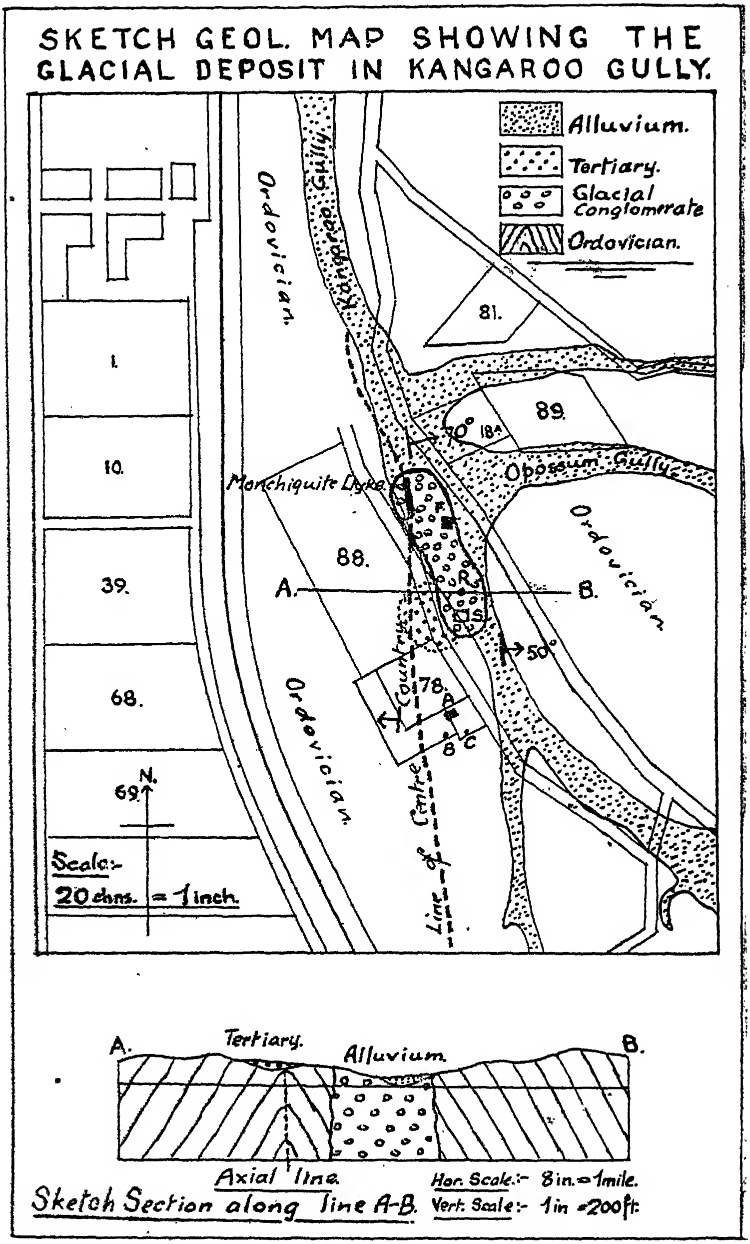
The deposit is best found by going about $3\frac{1}{2}$ miles about S.W. from Bendigo along the Bendigo Creek to its junction with Kangaroo Gully at Kangaroo Flat. A further $1\frac{1}{8}$ miles almost due south along Kangaroo Gully, brings one to its junction with an eastern tributary called Opossum Gully, and the north end of the deposit in question is seen in section on the west bank of Kangaroo Gully, about 120 yards south of its junction with Opossum Gully. The outcrop is roughly elliptical (see sketch map), the longer axis of the ellipse coinciding almost with the bed of the creek occupying Kangaroo Gully. The deposit is about 400 yards in length from north to south, and the width varies from about 40 to 70 yards.

Nature of Outcrop of Deposit, and Relations of Surrounding Rocks.

In places the deposit is masked by recent river alluvium, but generally the rock outcrops at the surface above creek level, and has been exposed probably as the result of alluvial mining. One or two small gullies running east and west cut through the deposit on the west side of Kangaroo Guly, and in one of these the deposit is seen in contact with vertical Ordovician slates and sandstones. The junction of the two rocks is almost vertical, and both rocks are overlain unconformably by recent alluvial material or hill wash.

Since Mr. Dunn's examination of the deposit two parties of miners, presumably under the belief that the deposit was superficial, and that alluvial gold would be found below it, have sunk two shafts and a bore into the deposit.

The most northerly shaft (shown at F on map), and referred to in this paper as the main shaft, is 2 feet by 5 feet in cross section, and 24 feet deep.



SKETCH GEOL. MAP SHOWING THE GLACIAL DEPOSIT IN KANGAROO GULLY.
Alluvium.
Tertiary.
Glacial Conglomerate
Ordovician.
Kangaroo Gully
Ordovician.
81.
1.
10.
89.
70°
Opossum Gully
Monchiquite Dyke
88.
39.
A.
B.
Ordovician.
50°
68.
Country
78.
Ordovician.
N.
69.
Line of Centre
Scale:-
20 chns. = 1 inch.
Tertiary.
Alluvium.
A.
B.
Axial line.
Sketch Section along line A-B.
Hor. Scale:- 8in.=1mile.
Vert. Scale:- 1in =200ft.

Fig. 1.

S.S.E of the main shaft a bore was put down at R on map to a depth of 104 feet, by two miners named Murphy and Busst, while still further S.S.E. at S. on the map, another shaft, sunk by other miners, named Jenkins and Bielski, penetrates the deposit for 55 feet, and by boring a further 10 feet a depth of 65 feet was reached.

All these shafts and bores continued in the deposit to the lowest depths reached, when sinking was abandoned.

The relations of the deposit to the Ordovician rocks is peculiar. The shallow section in the E. and W. gully, cutting the deposit shows an almost vertical contact between the two formations. Further evidence of a similar kind occurs near the bore at R on the map. Eighteen yards S.W. of the bore Ordovician slates and sandstones outcrop on the west side of the gully. They strike north 12 deg. west, and dip exactly at 80 deg. Since the bore penetrated the deposit for 104 feet, without reaching the Ordovician, it follows that the angle of contact between the deposit and the Ordovician must exceed 60 deg. The average strike of the Ordovician rocks near the deposit is north 10 deg.-20 deg. west. On the west side of the gully the rocks dip west at high angles, and on the east side they dip east at from 50 deg.-70 deg., as shown on map. An anticlinal fold or line of centre country therefore runs almost parallel with Kangaroo Gully, and the north-west part of the outcrop of the deposit crosses the axial line. This line is evidently the southerly continuation of the Bird's line of reef. The shaft of the Bird's mine lies 15 deg. west of true north from the deposit in Kangaroo Gully. Along this axial line a monchiquite dyke cuts the deposit as shown on the map at the north-west part of the outcrop. The dyke is about 1 foot wide, and has been traced on the surface for about 30 yards. The strike of the dyke is north 14 deg. west, and the dip is nearly vertical, but really at a high angle to the east. It is to be noted that the area occupied by Ordovician rocks on the map is left unshaded.

Some patches of Upper Tertiary sands, clays, and ironstones occur to the south-west of the deposit, as shown on the map, and are also indicated at the points A and B on the map. A is a small patch exposed in a dam; B is ironstone from a small dam, while C represents a shaft sunk 40 feet in Ordovician sandstone.

Distribution and Nature of Pebbles in the Deposit.

The vertical section exposed in the main shaft at F on the map shows from above downwards.

Silt, 18 inches.

Gravelly wash, part angular, part rounded—2 feet—2 feet 6 inches.

Volcanic agglomerate, with a few large pebbles and scattered rounded quartz grains—19 feet—19 feet 6 inches.

At shaft S, sunk by Jenkins and Beilski, the surface material contained many pebbles, but the material brought up in sinking the shaft consists almost entirely of fragmental volcanic material with small quartz grains scattered through it. Some fragments of altered Ordovician sandstone occur, and one of these is described later. It was reported to me that a large boulder was found near the bottom of the shaft, but of this I have no personal knowledge. The surface outcrops of the deposit generally show no bedding or sorting of the material, and contain abundant pebbles, some angular, some rounded, and some facetted, of various rocks, including quartzites, shales, and vein quartz. The pebbles occur with their longer axes irregularly disposed. In places rude bedding of the material is indicated principally by bands of varying colour. Mr. Dunn has referred to the occurrence of veins of chalcedony in the deposit. I found one such piece, evidently formed since the deposit, filling a cavity in the material and showing concentric banding, indicating deposition from solution.

The distribution of the pebbles suggests that they are only abundant near the surface. Mr. Dyason and myself, however, descended the main shaft at F on the map, and found, embedded two inches in the wall of the shaft 19 feet below the surface, a quartzite pebble, which is polished and facetted and almost certainly of glacial origin. Minute, rounded and angular quartz grains are not uncommon in the volcanic matrix wherever we examined it. Among the quartzite pebbles in the superficial part of the deposit a number were found which, while rounded, were also polished as if by glacial action, while one shown in Plate xxxii., Fig. 1 is a quartzite pebble, not only definitely facetted but showing on one face distinct glacial striations. There can be no doubt therefore that Mr. Dunn was right in describing the pebbles as glacial, although he did not obtain evidence, such as is described above, of facetting and striation among the pebbles.

Petrographical Characters of the Matrix of the Deposit.

As soon as I saw the deposit, even the superficial portion, I recognised the great resemblance of the matrix to an ultra-basic volcanic agglomerate. In hand specimen it is in some ways comparable to the material filling the volcanic neck at the Pennant Hills, near Sydney, New South Wales.

The microscopic and chemical evidence, it will be seen, entirely supports this view of its origin. As an example of the matrix at the surface one may cite an agglomerate (Plate xxxii., Fig. 2), occurring 40 yards south of the north end of the deposit. Glacial pebbles occur in this material. Under the microscope, (Sections No. 1009), there are seen large fragments of angular quartz, more or less corroded, and of Ordovician shale. Some secondary quartz filling cavities in the rock or replacing primary minerals can also be distinguished. The bulk of the rock consists of larger and smaller fragments of a very basic volcanic rock embedded in a finer volcanic paste or cement. Both fragments and cement are much altered, so that the rock is stained and impregnated with red oxide of iron.

The minerals present in the rock are olivine, now represented by pseudomorphs in serpentine, biotite in long lath-shaped crystals, now bleached and partially altered to hydromica, augite (?), possibly represented by granular iron-stained crystals, magnetite or ilmenite, and a base which is almost isotropic, and may represent glass or possibly analcite. The rock is essentially an olivine-biotite-monchiquite agglomerate, with fragments of quartz and Ordovician sediments. It resembles closely the monchiquite dyke which intersects the deposit, but differs mainly in the paucity or absence of augite.

As examples of the nature of the deposit below the surface, the following specimens may be described :—

Specimen from the main shaft (Section No. 1010), (Plate xxxii., Fig. 3). For chemical analysis, see below.

The rock is much altered. Porphyritic pseudomorphs in serpentine after olivine are abundant, the ground-mass showing granules and prismatic purple needles of titaniferous augite, and a colourless to brown isotropic matrix, which may be glass or analcite. Small water-worn and angular quartz grains occur, and are corroded, and some show a reaction rim, including minute prismatic needles, possible of hornblende. Some secondary silica occurs in the form of quartz and chalcedonic infillings or replacements. The

rock is essentially an altered olivine monchiquite, with larger and smaller foreign pebbles.

Fragments from Bore at F, occurring round the bore hole, depth unknown (Section No. 1020).

This rock is essentially similar to the last described. It is porphyritic and hyalopilitic, contains phenocrysts of altered olivine, and in the ground-mass purple prismatic titaniferous augite, with extinction angle of 40 deg.-46 deg., abundant minute magnetite or ilmenite crystals, and the remainder consists of brown isotropic material, probably glass. One corroded fragment of quartz is embedded in the rock. The rock is a fragment of an olivine monchiquite.

The monchiquite dyke cutting the deposit at its north-west end has the following microscopic characters, (Section, No. 1011), (Plate xxxii., Fig. 4). For chemical analysis, see below.

The olivine crystals occur as serpentine pseudomorphs. Abundant faintly purple augite needles, probably titaniferous, extinction angle 40 deg.-46 deg., and lath-shaped brown biotite crystals occur, but magnetite is practically absent. Some of the cavitites in the rock are lined with secondary chalcedony, and filled with pale serpentine. The ground-mass is colourless and isotropic, and may be glass or analcite.

The rock is an Olivine-Monchiquite.

From Jenkins and Bielski's shaft (S. on map) a large fragment of rock was found in the heap surrounding the shaft. Its nature was not at first recognised, but the chemical analysis quoted below, and the evidence in section under the microscope show that it is a fragment of Ordovician sandstone, which became embedded in the volcanic material.

In Section No. 1014, it consists of angular and sub-angular quartz fragments in a felspathic and micaceous cement. A band of argillaceous material partly iron-stained, and partly changed to chlorite occurs in one part of the section. The rock is an altered felspathic sandstone.

The Chemical Characters of the Rocks.

Analyses of the fragmental rock from the main shaft were made by Mr. T. H. Plante, B.Sc., and of the monchiquite dyke, and the fragment of ordovician sandstone from Jenkins and Bielski's shaft by Mr. H. C. Richards, M.Sc., Mr. E. O. Thiele, M.Sc., redetermined for me the alkalies in the fragmental rock from the main

shaft. All these gentlemen were, at the time the analyses were made, advanced students in the Geological department of the University. Their results are as follow :—

A.—Analysis of volcanic fragmental rock from main shaft, by T. H. Plante, B.Sc.; alkalies in above by E. O. Thiele, M.Sc.

B.—Analysis of monchiquite dyke, penetrating deposit in Kangaroo Gully, by H. C. Richards, M.Sc.

C.—Analysis of Ordovician fragment, from Jenkins and Bielski's shaft, by H. C. Richards, M.Sc.

D.—Analysis of monchiquite, from Central Red, White and Blue mine, Sheepshead line, by F. L. Stillwell, M.Sc. (Quoted from Proc. Roy. Soc., Vict., Vol. xxv. (new series), Part i., 1912, p. 4.)

	A	B	C	D
SiO_2	41.42	41.15	64.87	40.92
TiO_2	6.58	5.62	2.41	6.57
Al_2O_3	14.86	10.54	13.82	11.34
Fe_2O_3	13.36	13.21	3.95	.54
			FeO = 3.50	FeO = 12.96
CaO	2.72	10.70	tr.	9.28
MgO	0.38	7.28	1.23	7.78
				MnO = 0.13
K_2O	3.30	2.18	5.70	1.94
Na_2O	10.20	0.99	1.78	3.27
				P_2O_5 = 0.51
H_2O-	5.42	7.25	Loss on ignition = 2.40	0.64
H_2O+		2.15		1.77
CO_2	2.40	0.60		2.82
Total	100.64	101.67	99.66	100.47

Certain comments on the analyses are necessary. In the first place both A and B are very altered rocks. This may be regarded as explaining the high-water content (mostly in the serpentine), and the amount of CO_2 present in the rock. As the rocks were so altered, all the iron present was determined as Fe_2O_3. Allowing for these points, it will be noticed that there is a close resemblance in the analyses of the monchiquite dyke from Kangaroo Gully analysed by Mr. Richards, and that of the Central Red White and Blue mine analysed later by Mr. Stillwell.

The comparison between analyses A and B brings out some interesting points, and one very puzzling one. The percentages of silica, titanium oxide, and ferric oxide in the two rocks are so similar as to leave no doubt that the rocks were originally essen-

tially similar. This implies that the fragmental rock from the main shaft had originally the composition of an olivine-monchiquite. The microscopic evidence quoted above entirely supports this conclusion. However, the subsequent alteration of the two rocks has apparently been different. Whereas the content of lime, magnesia, and the alkalies in B, the monchiquite dyke, is quite normal for such a rock, the proportions in the fragmental rock are absolutely abnormal, the alkaline earths totalling only three per cent., while the alkalies total thirteen and a-half per cent. This implies the removal of the bulk of the alkaline earths present in the fresh rock, and the introduction of about 10 per cent. of alkalies, principally soda. At first I refused to credit the results of the analysis. Mr. Plante, however, determined the alkalies twice, and obtained a total of 12 to 14 per cent. for the determinations. At a later date Mr. Thiele re-determined the alkalies, and his results are included above. The microscopic examination fails to indicate in what mineral form the alkalies are present in the rock. There are no felspars, and while analcite may be present there is nothing in the appearance of the section to suggest its presence in large quantity. I am not aware of any similar type of alteration in an igneous rock having been previously recorded. There seems to be no doubt of the original nature of the rock, and of its present composition; the alteration has occurred, but I am quite unprepared to suggest the chemical and mineralogical changes by which the alteration has been effected.

The Origin and Age of the Deposit.

The evidence of the mode of occurrence of the deposit shows a probably vertical contact with the Ordovician, while the microscopic and chemical evidence shows that the bulk of the material, especially below the surface, consists essentially of fragments of an ultra-basis volcanic rock, a monchiquite agglomerate. The relations are suggested in the sketch section accompanying the geological map. (Figure in text.) Further, the chemical and miscrocopical evidence shows the closest relations between the agglomerate and the monchiquite dyke penetrating it. Elsewhere[1] Mr. Stillwell has suggested a correlation between the monchiquite dyke of Bendigo and elsewhere in Victoria, and some of the limburgites of the Macedon district,[2] which are not older than mid-Kainozoic, and

1 Stillwell *op. cit.*

2 Skeats and Summers. Geology and Petrology of the Macedon District, Bulletin 24. Geol. Survey of Victoria, 1912.

may be younger. If this correlation is correct, and it seems probable, the agglomerate of Kangaroo Gully, from its resemblance to the monchiquites, would be referred to the same age, i.e., not older than the mid-Kainozoic.

The evidence of the glaciated pebbles in the deposit, however, is important. We know of only one glacial period in Victoria, and that is of Permo-Carboniferous age. Two alternative explanations of this remarkable association of glacial pebbles in a monchiquite agglomerate suggest themselves, but neither is put forward with any great confidence.

On the one hand we may picture the agglomerate as at least of Permo-Carboniferous age, possibly older. The passage of the Permo-Carboniferous ice sheet over the area may have involved the ploughing up of the upper part of the agglomerate, and glaciated pebbles, with finer quartz grains, might in this way be embedded in the upper part of the deposit, where, in fact, they are most plentiful. As against this view we have the negative evidence that no other volcanic rocks of this character of Permo-Carboniferous, or pre-Permo-Carboniferous age, are known in Victoria, and the positive evidence that their known chemical and petrological analogies in Victoria are not older than mid-Kainozoic.

The alternative explanation is not without difficulties, but seems to me to be at any rate less improbable.

According to this view, one would picture the Bendigo Ordovician area partly covered by Permo-Carboniferous glacial conglomerate in mid-Kainozoic time. A volcano of explosive type reached the surface in Kangaroo Gully, bursting through the glacial conglomerate, and ejecting monchiquite agglomerate. Some of the glacial pebbles and finer material would be likely to become incorporated in this way in the agglomerate. Subsequent denudation of the area has removed all traces of the glacial deposit, except those pebbles which had become incorporated in the monchiquite agglomerate.

It may be suggested that the pebbles, while glacial, are derived not immediately from a Permo-Carboniferous glacial deposit, but have been handed down to a Kainozoic or recent river gravel, and have become incorporated in the agglomerate in comparatively recent times. This view I have considered and rejected, as a close examination of adjoining Kainozoic and recent river gravels showed a complete absence of glaciated pebbles, and a marked difference in lithological characters. On the whole, but with considerable diffidence, I think that the least unlikely hypothesis is the second

one stated, that the deposit is essentially a Kainozoic monchiquite agglomerate, formed from an explosive type of volcano, which, bursting through a deposit of Permo-Carboniferous glacial conglomerate, incorporated a certain proportion of glaciated pebbles and finer detritus among the volcanic ejectamenta, and that subsequent denudation of the area has removed all the glacial material except where the neck of the volcano is now exposed to view in Kangaroo Gully.

Summary.

A volcanic agglomerate, containing glaciated pebbles, and invaded by a monchiquite dyke occurs at Kangaroo Gully, near Bendigo. It junctions nearly vertically with Ordovician slates and sandstones, and appears to be the outcrop of a volcanic pipe, elliptical in outline, and stretching N.N.W. and S.S.E., about ¼ mile long, and 40-70 yards broad. The pipe has been penetrated by shafts and bores to 104 feet The bulk of the material consists of monchiquite agglomerate similar petrologically to the dyke which penetrates it. Chemical analyses show some similarities to the dyke, but it is abnormally low in alkaline earths (3 per cent), and abnormally high (13.5 per cent.) in alkalies. These results appear to be due to obscure subsequent alteration of the rock.

The agglomerate, especially near the outcrop, contains abundant pebbles, some of which are definitely glaciated, and contains scattered grains of quartz, apparently throughout. After considering various alternative explanations of the mode of occurrence, it is suggested as not improbable that in mid-Kainozoic times explosive volcanic activity formed a vent, which penetrated a deposit of Permo-Carboniferous glacial material, and incorporated some glacial pebbles with its fragmental ejectamenta. Subsequent denudation removed all traces of glacial material, except where it was embedded in the neck of the volcano.

EXPLANATION OF PLATE XXXII

Fig. 1.—Facetted and striated glacial quartzite pebble from outcrop of deposit in Kangaroo Gully. About ¾ natural size.

Fig. 2.—Photomicrograph, Section No. 1009, x 25 diameters Agglomerate type of deposit, in which glaciated pebbles occur. The section shows angular and corroded quartz, and fragments of monchiquite and quartzite in a volcanic matrix. Forty yards south of north end of deposit.

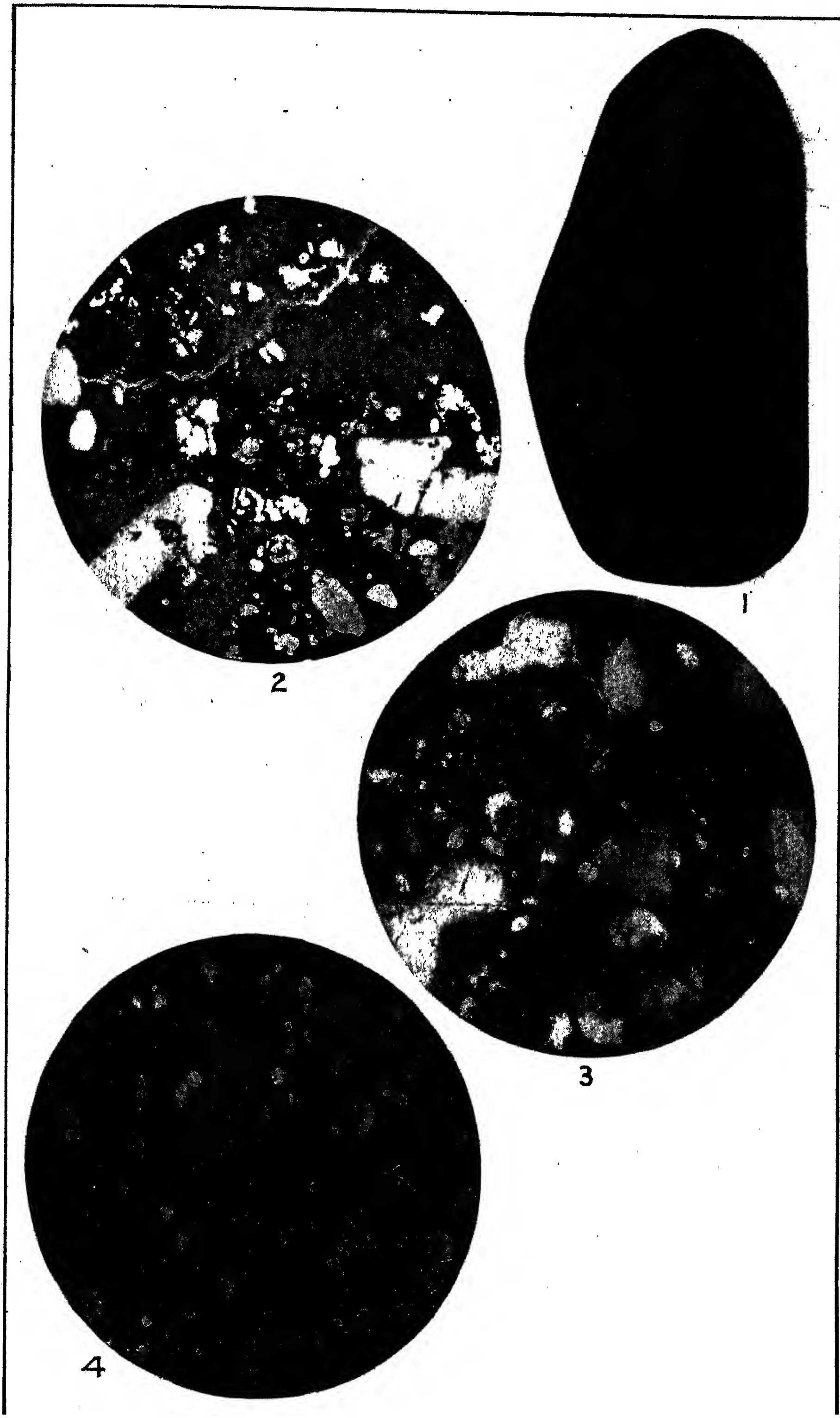

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Fig. 3.—Photomicrograph, Section No. 1010, x 25 diameters. Monchiquite type of matrix, containing glaciated pebbles. The section shows altered olivine, augite and magnetite, with, angular and corroded quartz fragments, and some secondary quartz. Material from main shaft, Kangaroo Gully.

Fig. 4.—Photomicrograph, Section No. 1011, x 47 diameters. Altered olivine monchiquite, with augite, biotite, etc. Dyke penetrating deposit near north end of outcrop, Kangaroo Gully.

Note.—The numbers of the rock sections have reference to the collection in the Geological Department of the University.

[Proc. Roy. Soc. Victoria, 26 (N.S.), Pt. II., 1914.]

Art. XXV.—*Physiography of the Mansfield District.*

By CHARLES FENNER, B.Sc.

(Kernot Research Scholar in Geology, University of Melbourne.)

[Read 11th December, 1913.]

Contents.

I.—Introduction.

The area dealt with in this paper may be roughly defined as that embraced in the central and eastern portions of the Shire of Mansfield. The parishes include—Nillahcootie, Dueran, Dueran East, Maindample, Barwite, Gonzaga, Mansfield, Beolite, Merrijig, Wappan, Loyola, Delatite, etc.

During 1913 I spent some months collecting data on the geology and physiography of the district, and this paper embodies the material collected under the latter head.

Physiographically, the Mansfield area is interesting, for at least three reasons :—

(a) It forms a part of the basin of the westward draining upper Goulburn River, the latter being an area of complex relief, and with many fine rivers.

(b) A variety of rock types, both igneous and sedimentary, occurs, and a corresponding variety of physiographic types is found.

(c) The sedimentary rocks are of various ages, with complex faulting, bringing further variety of physiographic features.

The upper Goulburn basin has moved several Victorian geographers to make speculations concerning it. It is distinctly impressive in Victorian mappings as the largest westerly draining valley in the State, and is easily noted, not only on contour maps, but on rainfall, population, and railway charts. The following detailed account of the Mansfield portion may help toward the elucidation of the bigger problems of the upper Goulburn.

II.—Previous Literature.

While there are no records of previous physiographic work in the Mansfield district, the following papers have been found very useful and suggestive :—

(a) Griffiths Taylor.—" Physiography of Eastern Australia," Com. Bureau Meteorology, Bull. No. 8, 1911.

(b) Jutson, J. T.—" Physiography of the Yarra River," Proc. Roy. Soc., Vic., Aug., 1908.

III.—Rivers and Creeks.

(1)—*General Description.*—(See fig. 1.)

In the north, Broken River, rising in the highlands that form the western boundary of the upper King, flows westerly, receiving the Bridge and Blue Range Creeks on the northern side. When it reaches the parish of Nillahcootie, it takes a sudden turn northward, and passes out through the Barjarg Gap, thence away over the Murray plains, past Benalla, where it divides into two streams. Further south, Ford's Creek rises in the low Springfield hills, east of Mansfield, flows west through Mansfield, and then south across Quartzite ridge to the Delatite. Burnt Creek and Howe's Creek

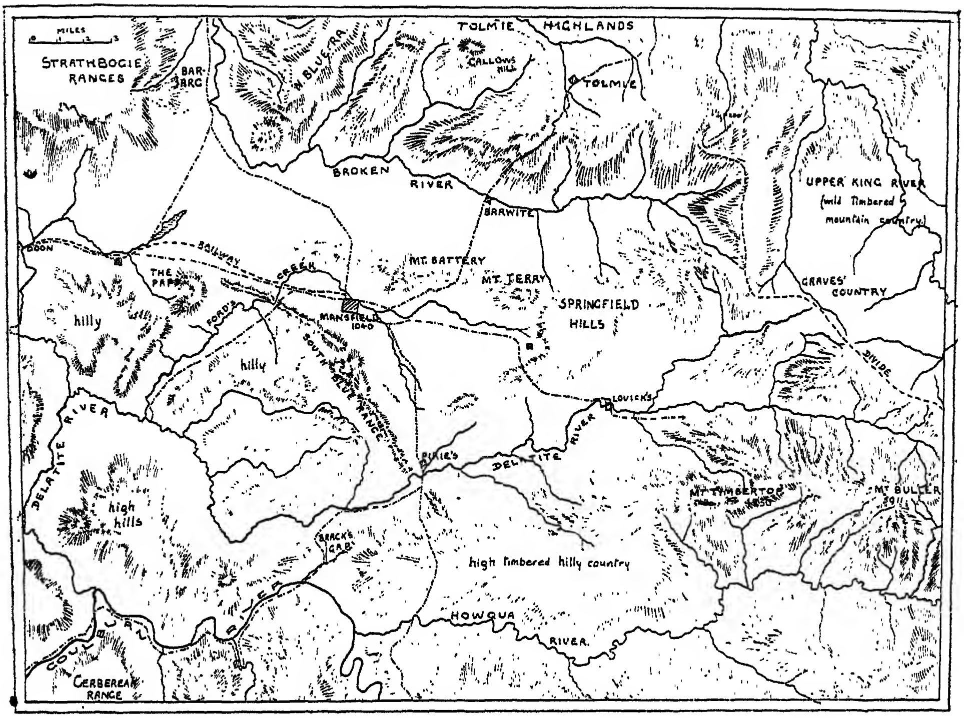

Fig. 1.—Map of the Mansfield district, with approximate relief; the dotted lines indicate main roads.

follow similar, though shorter, courses. The Delatite River rises in the elevated knot of granite and silurian country about Mount Buller, flows westerly, closely approaches the Goulburn at a low wind gap (Brack's Gap), then turns north, and then westerly, to the Brankeet Creek, where the Delatite takes a sharp turn southward, flowing into the Goulburn at the Sugarloaf. The Howqua is somewhat parallel with the Delatite, but rises further east, near Mt. Howitt. It flows west, junctioning with the Goulburn before the latter has taken the westerly turn. South of the latitude of the of the Howqua, the following streams are distinctly northward flowing:—Goulburn, Big, Jerusalem, Rubicon, Acheron, Yea, and King Parrot Creek.

(2)—*Detailed Account.*

(*a*) *Blue Range Creek.*—This pretty stream flows through interesting wooded country in the western part of the Tolmie Highlands. The valley is V-shaped, and has a fairly steep grade. The course

of the stream is almost wholly along the margin of the granitic mass of the North Blue Range. The latter was evidently a residual previous to the deposition of the lower carboniferous mudstones, and the present valley is due to the selective erosion of the softer rock along the junction. (See Fig. 6.)

(*b*) *Bridge Creek.*—This is the other important northern tributary of the Broken River. The valley is in the level-bedded carboniferous mudstones, and in its various gorges and cliffs the influence of the rectangular joint planes of the mudstones is very evident. Of the many surveyed railway routes to Tolmie, one is up this valley, but owing to topographical immaturity, the engineering difficulties prove a stumbling block.

(*c*) *Wild Dog and Back Creeks.*—These lie further to the north-west, and are both picturesque streams flowing through country of granite and indurated slates. Falls 150 feet high are mapped as occurring on both streams. Those on Wild Dog Creek are very fine in winter, and the aneroid under good conditions registered 300 feet from the base to the summit of the falls. Both streams are suggestive of "boat-hook bends," but whether they here bear the significance attached to such bends is not evident.

(*d*) *Broken River.*—Taylor, in his "Physiography of Eastern Australia," says, "An interesting problem awaits the Victorian student at Barjarg on the Broken River." As will be seen from

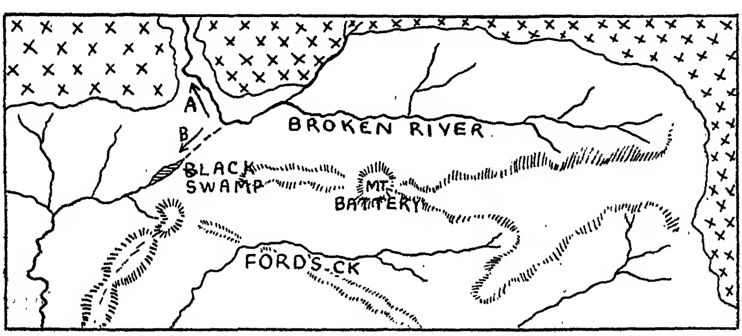

Fig. 2.—Sketch Map of Broken River; A=present course; B=old course.

Fig. 2, the upper Broken and Ford's Creek are parallel streams for a large part of their journey, both flowing in wide valleys in the soft Battery sandstones. As may be noted on any topographic map of the State, the upper Broken is within the natural mountain boundaries of the upper Goulburn. A line of low hills separates

Ford's Creek and the Broken River, and these gradually become lower as we go west. At the point (Fig. 2) where the Broken River

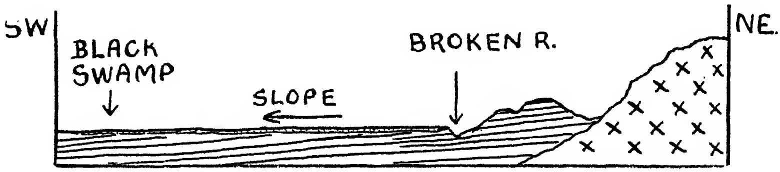

Fig. 3.—Enlarged diagrammatic section along dotted line B in Fig. 2.

takes its sharp northerly turn, there is no divide whatever. (See Fig. 3.) An examination of the area makes it quite evident that the upper Broken River originally flowed south-west through the Black swamp, and on to the Goulburn. There is a gentle slope south-west from the "elbow of capture," and deposits of coarse river pebbles (quartzites, black cherts and porphyry) also occur. These deposits have been opened up for road making, and are quite similar to those of the present Broken River. The capture has been made by a small stream heading back through the Barjarg Gap. The two signs of recent capture, as set out by W. M. Davis,[1] are to be found: (a) a trench (about 90 feet deep in this case) above and below the elbow of capture; (b) the absence of a small tributary at the elbow. The river, on turning north, passes through the Barjarg Gap, a striking valley, which will be considered later.

(*e*) *Ford's Creek.*—This small stream rises in the low Springfield hills, east of Mansfield, flows for some ten miles west across the Battery sandstones, and then turns south-west, cutting across the strike of the silurian to the Delatite. Its interest lies in the fact that, like the upper Delatite, the stream cuts through a very hard ridge of thick quartzite, really a continuation of the South Blue Range. (See Fig. 1.) It would appear to be a "superimposed stream," having had its south-westerly direction prior to the denudation that has left the quartzites standing as a low, but very definite and continuous ridge. The roads to Loyola and Jamieson take advantage of these two gaps.

(*f*) *Delatite River.*—This rises in the highlands about Mount Buller, and is snow-fed for a large part of the year. It flows west, and, while in the region of granites and hardened slates, the valley is steep, rugged, and V-shaped. (See Fig. 4.) Upon entering the level-bedded carboniferous sandstanes, the valley is wide and

1 Geographical Essays, p. 602.

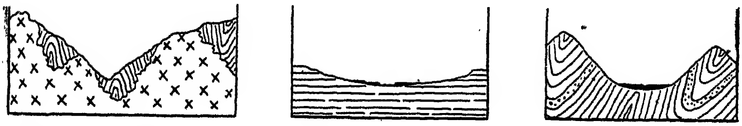

Fig. 4. –Showing the nature of the Delatite Valley in (i.) Granites and slates; (ii). Soft level-bedded mudstones; (iii.) Silurian shales.

terraced, showing here the influence of the rock on the "age" of the valley. Crossing Quartzite Ridge the river is again narrowed, and when it fairly enters the folded silurian shales, we have a return to a more V-shaped valley as diagrammed in Fig. 4. Taylor[1] refers to "the extraordinary path followed by the Delatite; it seems to be heading straight for the Strathbogie Ranges, and then flows sharply south to junction with the Goulburn."

(*g*) *Goulburn River*.—For the first forty miles the Goulburn flows almost north. After receiving the Howqua, it turns west; it is joined by the Delatite on the north, and the Big River on the south; passes through a narrow valley at the Sugarloaf, thence flowing

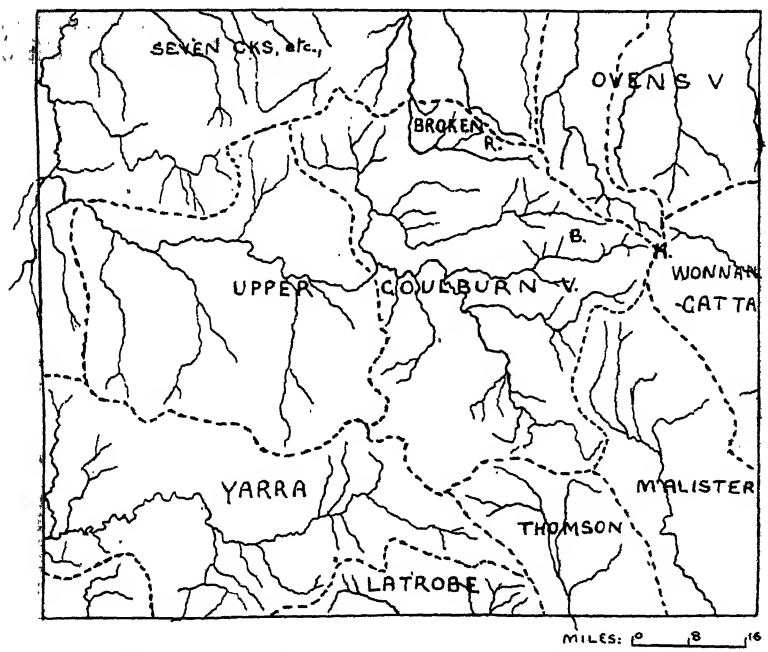

Fig. 5.—Map of the Chief Rivers and Divides (dotted) related to the Upper Goulburn River.

1 Physiography of Eastern Aust., 1911.

westerly to Trawool, where it again turns north to the Murray. It is evident from its varied course (Fig. 5) that it has suffered many changes, since its present valley is far from being the harmoniously branched whole that follows from the uninterrupted development of a large river through a long period of time. (See Fig. 5). As stated, the upper Goulburn has attracted much attention.

Skeats (Records A.A.A.S., Brisbane, 1909), suggests that the divides have been determined by differential denudation, being mainly outlined by plutonic masses. Jutson (Proc. Roy. Soc., Vic., 1911) agrees and believes that the Goulburn has enlarged its territory at the expense of the Yarra and Thompson Rivers. Gregory (Geog. of Vict.) regards the middle Goulburn as a lately developed stream that has captured the King Parrot, Yea and Acheron Rivers from the Yarra valley. Taylor (Physiography Eastern Australia) suggests that the old divide ran from Torbreck to Howitt.

In the absence of reliable topographical maps, and in view of the large area concerned, combined with the rugged and unsettled nature of most of it, it is very difficult to arrive at the truth of the matter. Certainly most maps are misleading, the hachures usually failing to distinguish between comparatively low hills and high resistant mountains. Important ridges are sometimes left out of the maps altogether. In support of the idea that the Goulburn originally flowed north through Barjarg Gap (see Fig. 10), the following considerations may be advanced :—

(i.) Such a course would bring the Goulburn into a harmonious parallelism with other Vict. rivers draining to the Murray.

(ii.) The Barjarg Gap is itself evidence of a highly significant nature.

(iii.) Other gaps such as Brack's Gap (see Fig. 1) also occur, and may mark the old valley.

(iv.) There is a definite north and south mass of highlands which would appear to have been the old western boundary of this valley. These are the Cerberean Range, continued north through the Puzzle Range to the Strathbogies. Through these highlands the only exit westerly is by the narrow valley at the Sugarloaf, west of Darlingford. (See Fig. 5.)

IV.—Mountains and Hills.

1.—*General Description.*

In the northern part of the area (Fig. 1) are the Tolmie highlands. These extend from the Barjarg Gap on the west to the

upper King River on the east, and are in places over 3000 feet in height. Northerly, they slope to the Murray plains, and, on the south, end suddenly in a fairly well defined fault scarp. In the centre of the wide lower carboniferous valley of Mansfield arises Mt. Battery (1760 ft.) and Mt. Terry. This country is all settled, and utilised for dairying and grazing.

Bounding the Mansfield valley, and running N.W.-S.E., is the South Blue Range, with its continuation, the Quartzite Ridge. Further south is the dissected silurian peneplain.

To the East of Mansfield there is a magnificent mountain skyline, including "Graves' Country" (Bainbridge Range), Mt. Buller (5911 ft.), and Mt. Timbertop, or Warrambat (4230 ft.).

2.—*Detailed Accounts.*

(*a*) *Tolmie Highlands.*—This interesting group is apparently a residual tableland of an average height of over 2000 ft. In the south it is in a youthful stage of dissection. In the west, Mt. Samaria and the North Blue Range are of intensely folded and hardened silurian slates, largely intruded by granitic rocks. The

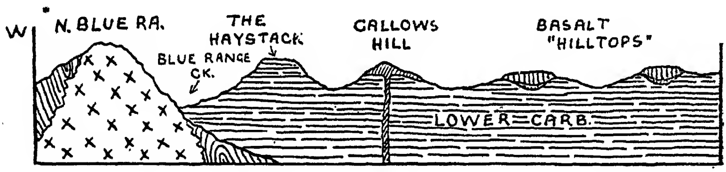

Fig. 6.—Diagrammatic section through the Southern part of Tolmie Highlands.

southern portion is mainly of level-bedded purple Battery mudstones and sandstones. To the north, it is mapped as dacite and porphyry, while conglomerates and sandstones occur again on the East. Volcanic rocks, apparently of both older and newer series, also occur.

The southern boundary of these highlands has been referred to as a fault line. The evidence may be summed up as follows :—

(i.) Slickensided rocks occur, but not abundantly.

(ii.) The ascent from the comparatively low country about Mansgeld to Tolmie is very steep, rising over 1600 ft. in four miles by the best road.

(iii.) The nature of the denudation on the two sides of the Broken River presents an extreme contrast.

North Side.	South Side.
i. Deep V shaped valleys.	Wide, open, level country.
ii. Streams at high grade.	Streams almost at base level.
iii. Cliffs and waterfalls.	
iv. Timbered and thinly populated.	Cleared and well settled.

Added to this is other evidence on the eastern and southern margins of what may be called the Mansfield Senkungsfeld, which will be dealt with further on.

(*b*)—"*The Hilltops*" *and Gallows Hill.*—The chief product of Tolmie is potatoes, grown in the rich volcanic soil of the hilltops. From one such farm, about 3000 ft. above sea level, the owner stated that it cost £2 7s. 6d. per ton to place his potatoes on the Melbourne market, owing to transport difficuties. Although Nature has provided Tolmie with patches of excellent soil, she has given a physiography which is severely against progress. The hilltops of older basalt are similar to those occurring in many other places in Vic. (See Fig. 6.) This leads to the anomaly of cultivated hills and heavily-timbered valleys.

Gallows Hill is the only "hill of accumulation" known in the district. The accompanying diagram (Fig. 6) shows the main features of the southern part of the Tolmie highlands.

(*c*) *Mount Battery.*—This hill (1760 ft.) is an interesting example of the influence of internal structure on external form. The level-bedded rocks give it its flat top and characteristic and numerous ledges and scarp faces. (Fig. 10.)

(*d*) *Mt. Terry and Springfield Hills.*—These are in the lower carboniferous sandstones east from Battery, and present an absolutely different appearance. They have a fairly steep dip westerly, and the difference in the topography thus brought about is striking. (Fig. 7). It appears that the eastern boundary of the Mansfield

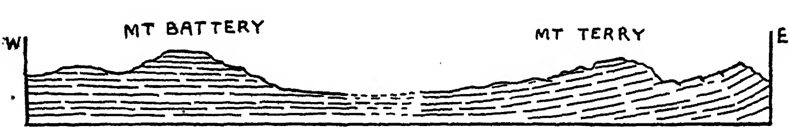

Fig. 7.—Section to show structure of Mts. Battery and Terry.

senkungsfeld, instead of rupturing and faulting, has "sagged" down as may be seen looking northward from Ingomar.

(*e*) *South Blue Range.*—Though not high, this range presents a barrier between Mansfield and the country to the south. The gaps utilised for roads are where the Delatite and Ford's Creek cut through the ridge. There is another gap called Monkey Gully, apparently formed by the cutting back of two streams, but this is not much used. The determining feature of this range is a series of quartzite beds usually dipping at a high angle. Massive conglomerates also occur at "The Cliffs" and "The Caves," and three of the highest peaks are due to the presence of plutonic rocks. In its lower parts, the range is composed of a series of hogbacks. It is further interesting, physiographically, as the southern boundary of the Mansfield senkungsfeld. Intense slickensides, with abundant, well-polished surfaces, have been traced for 15 miles along the range.

(*f*) *Cave Hill, etc.*—An interesting knot of hills occurs south of Mansfield in the S. Blue range; the chief points may be noted as follows:—Cave Hill: Largely porphyry, with level Battery sandstone above. Monkey Hill: A centrocline of red sandstone, the beds dripping inwards in all directions at about 45 deg. The Lookout and Porphyry Peak, dominant points in the range, are of quartz-porphyry.

(*g*) *The Paps.*—These twin hills, over 2000 ft. high, rise quite suddenly from the flats to north and east. The rock throughout is quite uniformly of silurian slates. The physiography on the east is less mature than on the west, and with further knowledge of the surrounding physiography these hills will probably be found very significant.

(*h*) *The Darlingford Hills.*—These are of silurian slates, and are typically of the Sugarloaf type; somewhat conical. This is apparently due to the occurrence of more resistant vertical beds, combined with valleys cutting across the strike. The hard beds which have determined the hills may be noted outcropping even from a long distance.

(*i*) *Mt. Buller.*—About 25 miles eastward from Mansfield, one of the most important knots in Victoria culminates in the pinnacle of Mt. Buller (5911 ft.). Although Buller is the highest peak of this knot, Mt. Howitt (5715 ft.) is more important physiographically. (See H in Fig. 5.) To the west and east of Buller occur areas of purple sandstones, these presumably having been denuded away from the intervening area. Their absence is, however, of long standing, dating back prior to the older basalt flows. (Fig. 8.) The older basalt, which occurs on Mount Buller, preserves one of the

highest early tertiary valleys thus formed in Victoria. Similar basalt occurs on Mt. Howitt, but here the underlying rock consists of purple mudstone. The rivers on either side of Mt. Buller at

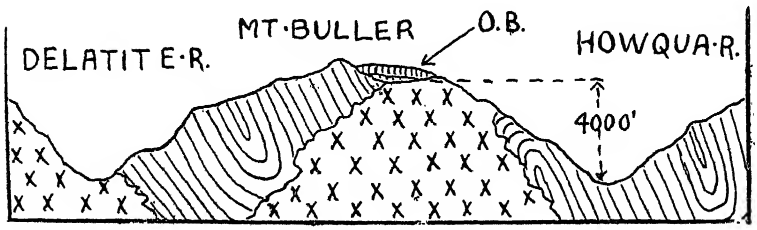

Fig. 8.—Diagrammatic section from North to South through Mt. Buller (6911 feet).

present flow in valleys 4000 feet below the old valley preserved under the Older Basalt. Since the latter rocks occur in conjunction with fossiliferous beds otherwhere in Victoria, the fact may form the basis for some estimation of the amount of erosion in tertiary times. Similar evidence occurs at the Dargo High Plains, Mt. Feathertop, etc.

(*j*) *Mt. Timbertop.*—This mountain, nearer Mansfield and more easily accessible than Buller, has a somewhat complex structure. (Fig. 9.) Its table-top is a long, narrow outlier of level-bedded,

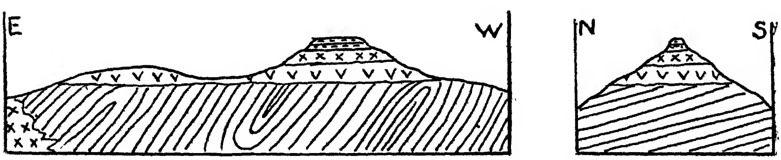

Fig 9.—Diagrammatic sections showing structure of Mt. Timbertop.

coarse sandstones. The summit is 1600 ft. lower than that of Mt. Buller, and since it is of easily weathered material, it will not be long, "as the earth views time," before the sandstones will have disappeared from Timbertop, as they have done further along the ridge, exposing the more resistant underlying volcanics.

V.—Other Features.

(*a*) *Barjarg Gap.* (See Fig. 10.).—This outline sketch is sufficient to show that the gap is a very important one. Summers[1]

1 Geology, Proposed Nillahcootie Water Conservation Area. Proc. Roy. Society Victoria, 1908.

describes the extremely resistant nature of the rocks at this point. It appears impossible that the small Broken River carved this valley. As has already been mentioned, it is not unlikely this feature once formed the outlet of the northward-flowing Goulburn.

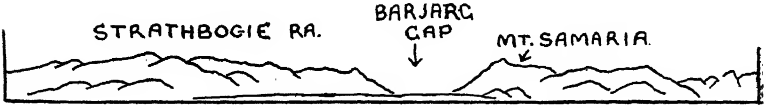

Fig. 10.—Barjarg Gap as seen from the South.

(*b*) "*Power's Lookout.*"—The diagram (Fig. 11) indicates a phase of the physiography of the upper King River. For several miles the coarse, level-bedded conglomerates cap the tableland. The conglomerate is traversed by joint planes, and it is due to the widening of one such crack that we have the rugged scenic effects of "Power's Lookout."

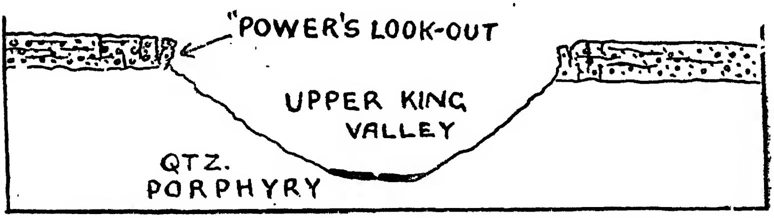

Fig. 11.—Erosion of King's Valley at Power's Lookout.

(*c*) *Junction of Delatite and Goulburn.*—A survey has recently been conducted by the Water Supply Department with a view to constructing a weir at the Sugarloaf, below the junction of the Delatite and Goulburn. By the courtesy of Mr. R. Comer, who was in charge of the survey party, I have been supplied with much valuable information bearing on the probable history of the Goulburn. The survey records show that of the two streams at the junction, the more northerly was originally the stronger stream, which is consistent with Fig. 15. Large deposits of alluvium have been proved to occur here also. The gap through which the river flows is very narrow, and V-shaped, the sides sloping up practically 1 in 1, to well over 1000 feet on either side. The plans also show indications that the Goulburn originally flowed northward through Brack's Gap.

VI.—Progressive Physiography of the Area.

At least three of the great deformative movements that have affected this area have left very definite traces in the folded strata of the various ages. These are shown in Fig. 12. The lowest of the three diagrams represents the intense crumpling and faulting undergone by the upper ordovician, as seen on a small scale in the face of the phosphate mine near Mansfield. Howitt[1] has mapped the strike of these rocks as trending N.W.-S.E. The central diagram is an ideal section through the Loyola hills, where the folding, though steep, is less severe than in the ordovician. The strike is regularly N.W.-S.E. The topmost of the three figures represents a long, low fold in the lower carb., as seen in section on the Broken River at Nillahcootie. The folding in these Battery beds is generally very slight; although there is much deviation, the general dip is, as stated by Dunn,[2] gently S.W. This gives a third N.W.-S.E. strike.

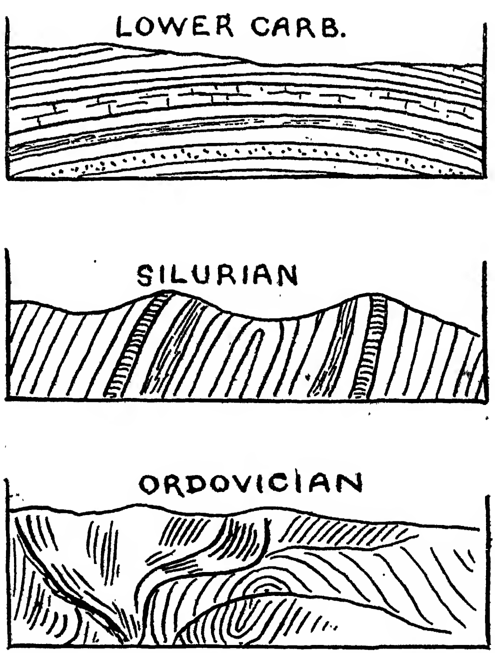

Fig. 12.—Sections showing the comparative folding of strata of different ages.

1 Report on Phosphate of Alumina Beds near Mansfield, Rec. Geo. Sur. Victoria I., 1, 1906.
2 Reports of Mining Registrars. Dec., 1889, p. 69.

It is interesting to note that the post-ord., post-silurian, and post-lower-carboniferous deformations appear, in this area, to have consistently folded the beds with N.W.-S.E. axes.

The general trend of the tertiary crust movements here are more difficult to determine. The reading of the recent physiographic history is greatly retarded by the absence of a reliable contour map. Since physiography is a science of much economic value, it may be fitting here to add another voice to the increasing demand for a Federal Contour Survey.

The upper Goulburn Valley has already been discussed in this paper, and evidence has been adduced toward proving that the present upper Goulburn consists of the headwaters of two original northward-flowing streams. By means of the diagrams (Figs. 13 to 16), endeavour will be made to elaborate this theory. While there is no doubt that differential denudation has played a large part in the formation of this valley, it is very probable that another factor was block-faulting, similar to that proved by Hart for the western part of the Victorian Divide, and similar also to that which has dominated the physiography of the neighbouring area of south-eastern New South Wales. (Taylor.) Jutson has also shown that faulting has played a part in the formation of the adjacent valley of the Yarra.

The inharmonious arrangement of the Goulburn and its tributaries has already been pointed out. The sharp northward bend of the Broken River at Barjarg (Fig. 2) has been noted by many physiographers; old maps of Victoria, indeed, show that certain cartographers had rearranged the mountain chains[1] in order to make this feature look more normal. Further, the discordant nature of the windings of the lower Delatite before entering the Goulburn (Fig. 1) is surely significant of some important crustal movement. We may accept the main divide of Victoria as being a physiographic feature of very long standing, say, back to early tertiary times. Of this physiography we have some remnant in the older basalt cappings of central and eastern Victoria. From such relics, of whose relative heights we have unfortunately little knowledge, it would seem to be an impossibility to reconstruct, even very roughly, those ancient river systems. Especially so, when we consider the disturbed state of eastern Australia in late tertiary times, and the fact that, as shown in Fig. 8, streams such as the Howqua have eroded their valleys over 4000 ft. in very hard rock since the older basalt period.

1 Map of Victoria by J. Bartholomew.

In the following description prominence is given to block-faulting to account for the physiography, and it may be well to sum up the strong evidence in favour of this.

(a) Hart has demonstrated block-faulting in the Western Divide (Grampians, Pyrenees, etc.); these faults run roughly north and south with the blocks tilted upward in the east, and downward in the western part.

(b) Taylor proves that similar features have played a very important part in the physiography of South-eastern New South Wales.

(c) The area under discussion, where closely examined, gives clear evidence of extensive faulting.

(d) Slickensides are abundant here, being traceable for 15 miles along one fault line.

(e) The mapped outline of the granite of the southern Strathbogies is very suggestive. (See Geol. Map of Vict.).

The collecting of stratigraphic data to prove this block-faulting would be, with the present knowledge of the area concerned, practically an impossibility. It can only be said that the physiographic evidence is such as to give rise to the hope that future stratigraphical research here will give a final proof to the theory of block-faulting.

We may assume two huge fault-blocks in the area concerned; one with its high eastern part running north and south in the neighbourhood of Mt. Buller, and dipping westward to the base of the next block, whose uptilted edges are indicated by the Cerberean and Puzzle Ranges.

To the sinking of the eastern block may be perhaps attributed the preservation of the lower carboniferous beds of Mansfield, while the only relic of similar beds on the fault-block to the west may be the small patch of sandstones and mudstones of the Cathedral Range.

Fig. 13 is an endeavour to represent the present upper Goulburn Valley as it would appear if it had quietly developed as a western flowing stream, without the interference of crustal changes during its career. A comparison of this figure with the actual upper Goulburn (Fig. 16) will be interesting.

Fig. 16 shows the two northward flowing streams which have been postulated, the eastern one passing through the Barjarg Gap. Both streams have a tendency to drainage from the eastward, which would be a natural consequence of the tilting of the block. This tendency to receive the chief tributaries from the east is noticeable in many of our present northern streams.

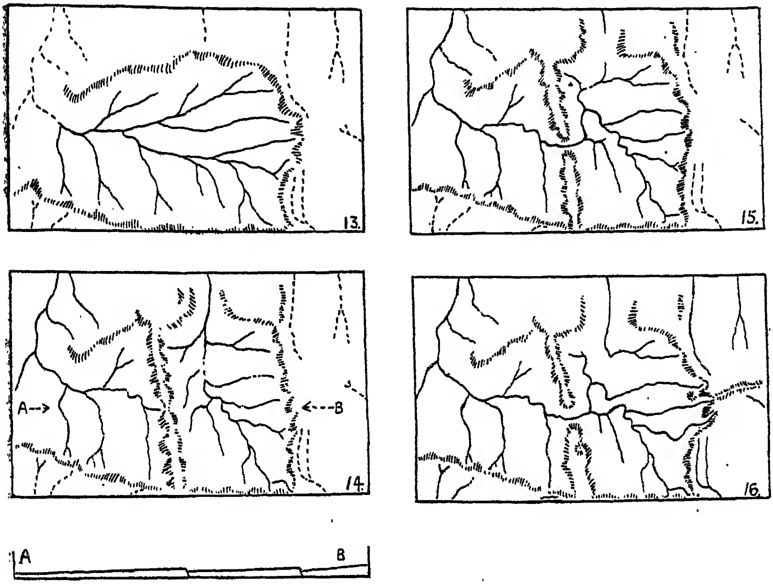

Fig. 13.—The Upper Goulburn as it would have been had it developed uninterruptedly as a western flowing river.

Figs. 14 and 15.—(with Section A B). Reconstruction of the rivers as outlined in the context.

Fig 16.—The Goulburn as it is to-day.

In Fig. 15 it is pictured that, in the progressive movement of the fault blocks, the country has "sagged" along a central E. and W. line. This would cause the river to relinquish its northern valley and dam up against the tilted edge of the next block. Through the least resistant part of this range the river would then cut its way (Fig. 15), and thus take up its journey westward.

Later a northward flowing stream, heading back through the Barjarg Gap, captured the Broken River, and we have the present physiography as outlined in Fig. 16.

It is suggestive and instructive to know that when the goldfields opened at Wood's Point and Jamieson, on the Goulburn, bullock-drivers with their waggon loads of provisions used to make the journey from Benalla, south through the Barjarg Gap, on to the Delatite, across Brack's Gap, and southward up the valley of the Goulburn. This is approximately the course of the stream as indicated in the foregoing paragraphs.

In conclusion, while no problems are solved in this paper, slightly more definiteness has been given to those already known, and a collection of material is presented which may help future workers in the area.

I am greatly indebted to Professor Skeats for his kind visits to me at Mansfield, and for his guidance and suggestions. Thanks are also due to the many residents of Mansfield who helped me to see as much as possible of the district during my stay there. The "Geographical Essays" of Professor W. M. Davis have been a constant source of inspiration.

INDEX.

The names of new genera and species are printed in italics.

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END OF VOLUME XXVI.

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END OF VOLUME XXVI.

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